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were balloted for and duly elected Fellows of the Society.

The Babylonian Astronomy. By R. H. M. Bosanquet, Esq., and Prof. A. H. Sayce.

No. 2.

The history of the Cuneiform Inscriptions may be divided into three periods, which correspond roughly with the three millennia before our era. The earliest of these periods, preceding 2000 B.C., is one of which we know definitely but little. The habit of copying ancient documents seems, however, to have preserved to us through the later periods some not inconsiderable remains of the earlier one. These are recognisable partly by their being in the Accadian language, and partly by the statements of the scribes who copied them, to the effect that they were copies of ancient tablets. The rules of the calendar, the consequences of which were deduced in our last communication, appear to be relics of this early period.

The astronomical documents which appear to belong to this period are for the most part connected with portents, or divination. When the astronomer observed any phenomenon, he was not, as a rule, particular about recording the astronomical circumstances attending it, but connected it with the events of the day. Large numbers of observations of this character have come down to us; and these are, of course, useless for any purpose of interpretation.

There is also a certain number of documents existing, which appear from their language and surroundings to descend from this early period, and yet afford some data towards interpretation. But, so far as we know, none of these documents bear anything of the nature of a year date.

The next period, comprising roughly the second millennium B.C., saw the replacement of the Accadian by a Semitic language. We know little more in an accurate manner of this period than of the first, as regular year dates were not in use in the astronomical records till just at its close.* So far as our subject is concerned, we are disposed to regard this period as the period of copying, of collection, and of commentary on the ancient observations. We shall have occasion to analyse a series of observations of *Venus*, portions of which are undoubtedly of high antiquity; and we shall in that case be able to detect the remarkable result of the passage of an ancient document through the hands of transcribers or commentators, themselves apparently unfamiliar with the phenomena dealt with.

The third period, the millennium preceding our era, may be called the Assyrian period. It is, as compared with the other two, a period of modern history. The Assyrian Eponym Canon, which has been given to the public by the late George Smith, covers a portion of the earlier part of this period, and affords year dates throughout its extent. Certain eclipses falling within these limits are sufficiently defined with respect to the history for their astronomical verification to have been treated already as a matter of importance. The language of the inscriptions of this date is also much clearer, and the observations are more complete than is the case with inscriptions of the earlier periods.

The observations have not year dates generally attached to them even in this period, though it is occasionally the case that the date can be determined within a few years.

We shall see that observations of the equinox exist which belong to the third period. These are incompatible with the continuation up to that time of the ancient Babylonian Calendar sketched in our former communication. The change of calendar will therefore present a distinct problem. We shall not be able to solve it completely without more evidence than is at present at our disposal.

* Dates reckoned from particular events, or by the years of a king's reign, were employed in the public records.

We shall in future abstain from making use of any special hypothesis as to the nature of the position denoted by the words "parallel to *Icu.*" We shall assume that this position is sufficiently represented by the circle of longitude through *Capella*. We thus disregard the small hypothetical correction made use of at the end of our former communication. Such a correction can be applied when desired to the more general values.

To compare the equinoxes under the ancient rule, cited in our former communication, with those of the two equinox inscriptions of Assurbanipal, supposed to be dated about 650 B.C.

Using the rule at the end of our former communication, we find that the difference between the falling of the equinoxes would be something over 20 days, supposing the calendar to go on unaltered. The cases would be as follows:—

Early period (2120 B.C.; longitude of *Capella*, 24° 37′).

1 Nisan.	Sun's longitude in normal year	=	$24\frac{1}{2}$°	-15° = $9\frac{1}{2}$°
	,, ,, mean year	=		$-5\frac{1}{2}$
	,, ,, latest year	=		$-19\frac{1}{2}$

Whence,

Earliest equinox	=	$-9\frac{1}{2}$	Nisan
	=	$20\frac{1}{2}$	Adar
Mean ,,	=	$5\frac{1}{2}$	Nisan
Latest ,,	=	$19\frac{1}{2}$	,,

At the time of Assurbanipal the equinox was $20\frac{1}{2}$ days earlier, or thereabouts; so that, supposing the ancient calendar to continue, the equinoxes would fall as follows:—

Later period (650 B.C.).

Earliest equinox	= 0	Adar
Mean equinox	= 15	,,
Latest equinox	= 29	,,

and the equinox could never fall in Nisan at all, according to the ancient rule.

The equinox inscriptions of Assurbanipal are as follows. There are no dates; the approximate date is supposed to be known from the character and style of the inscriptions, and the dated tablets with which they are associated. (*Western Asiatic Inscriptions** (published by British Museum), iii., 51, 1; *Trans.*

* This publication is generally referred to as *W.A.I.*, which abbreviation is used in what follows.

Soc. Biblical Archæology, iii., 1, 1874, pp. 229, 230.) "The sixth day of Nisan the day and the night were balanced. There were six kaspu of day and six kaspu of night . . . ." (*W.A.I.*, iii., 51, 2.) "The fifteenth day of Nisan the day and the night were balanced. There were six kaspu of day and six kaspu of night."

It is therefore clear, if we suppose that the Assyrians were then able to measure time with any accuracy, that the old rule must have been modified, if the date of these inscriptions is correctly referred to the later Assyrian period. These equinoxes would have agreed well enough with the working of the rule at the ancient period. The most probable view as to the nature of the change seems to be that at the later period there was direct dependence on the equinox.

We get from the above the definition of "kaspu" as a measure of time—the double-hour. This corresponds to the primary division of the heavens into 12 parts, of which we find abundant traces.

Division of the Circle.—Reckoning of Longitude.

The divisions of the circle which we find employed are those into 8, 12, 120, 240, and 480 parts. It has been assumed that the division of the circle into 360 parts was commonly practised by this ancient people. There is, however, no authority in the inscriptions for this assumption. It seems to have been derived originally from Achilles Tatius; and the preconceived idea thus introduced appears to have caused even those most conversant with the inscriptions to see the division of the circle into 360 in matters which do not involve it. An example of this is the sexagesimal reckoning of numbers, which is one of the common methods used in the inscriptions. It is hardly doubtful that the division of the circle as practised by Ptolemy, and in modern times, was an outgrowth of the sexagesimal method of the inscriptions. But the latter does not contain the former.

The numeration of the inscriptions is by two methods, sexagesimal and decimal. The decimal method is in all respects comparable with our own, and was used by preference in the Assyrian period. In it words and signs were used which were precisely equivalent to our "hundreds" and "thousands."

In the sexagesimal method the reckoning was the same as in the decimal up to 60. 60 was 1 soss. The counting went on by multiples of 60 + number over, up to 1 ner = 600. Then by ners + sosses + number over, up to 1 saru = 3,600. The numbers used are always taken in this way. There is no instance of counting by 60, 360, 3,600. The formation of the number 360 was not therefore a natural step in the sexagesimal arithmetic of the inscriptions.

The division of the circle into 480 parts is illustrated by a tablet in the British Museum, written in Accadian, which treats

of the Moon's position during a month. The numbers are, many of them, unintelligible or corrupt; this being, no doubt, partly due to the fact that the tablet is a copy of an ancient one, probably of date before 2000 B.C. But there is amply sufficient left to show that there was a real division into 480 parts, the Moon's mean daily motion being 16°, as it should be roughly, throughout the more intelligible portions.

The numbers of the tablet are as follow :—

1	The 1st day the Moon advances			5°*
2				10
3				20
4				40
5				80
6				96
7				112
8				128
9				144
10				160
11				176
12				192
13				208
14				224
15				240
16	The 16th day for	224°	of advance it { becomes obscure† / retrogrades }	16°
17		208		32
18		192		48
19		176		64
20		160		80
21		144		96
22		128		112
23		112		128
24		96		144
25		80		30
26		32		56
27		23		12
28		15		26
29		$5\frac{1}{20}$		$4\frac{2}{3}$
30	The 30th day the Moon is the god Anu.			

* The mark of degrees is here used to represent the units of the division of 480.

† This is the literal rendering of the Accadian word.

The numbers from the 1st to the 5th day are unintelligible. At the 25th day the right-hand column, and at the 26th the middle column, also become so. The final line is explained by the following passage (*Trans. Soc. Bibl. Arch.*, iii. 1, 209):—

"From the 1st day to the 5th day (the Moon is) Anu; for five days (it is) Hea; to the 15th day the orbit during the day is Bel" . . . . Showing that the new Moon was said to be Anu for five days, Hea for five days, and Bel for five days.

From the middle of the above numerical list it is sufficiently clear that the Moon's synodic revolution was supposed to be divided into 480 parts. The entry on the 16th day is intelligible if we read:—

"The 16th day it is 224° from the Sun, and 16° advanced on its waning course." We can ascribe to the words no other meaning which makes sense. According to this, the measure was taken the shortest way round the circle.

FRAGMENTARY PLANISPHERE, S. 162, BRITISH MUSEUM.—DIVISIONS OF CIRCLE INTO 120° AND 240°.—ORIGIN OF LONGITUDE.

Fig. 1. represents a small fragment of a planisphere. It contains two compartments, each of which is characterised by the name of a month. The month Marchesvan is the 8th, and Cislev the 9th. The arcs have, at their left-hand corners, the numbers shown.

This remarkable fragment is sufficient to determine the following table, in which the year is supposed to be divided into twelve mean months:—

PLANISPHERE S. 162.

	No. of Month.	Outer Circle.	Inner Circle.
		40	20
	1		
		20	10
	2		
		240	120
	3		
		220	110
	4		
		200	100
	5		
		180	90
	6		
		160	80
	7		
		140	70
Fragment	8		
		120	60
	9		
		100	50
	10		
		80	40
	11		
		60	30
	12		

The late G. Smith proposed to read 150 for 140, and 75 for 70 (see *Assyrian Discoveries*). There is no foundation for this, except the preconceived idea that the circle ought to be divided into 360 degrees. The numbers are imprinted on the clay with great clearness according to the sexagesimal notation.*

In this fragment the numbers are counted round in the negative direction of the signs; a most curious point. There is no doubt about it, as one of each pair of numbers given is greater than the half-circle in each case; so that the reverse counting cannot arise from reckoning round the nearest way, as in the case of the lunar longitudes above mentioned.

Further, it is to be noticed that the origin of these longitudes does not coincide with the beginning of the year. Of this arrangement we shall obtain an explanation.

We proceed to notice a point of a remarkable character which arises from this fragment, and furnishes a firm basis for two identifications of fundamental importance.

The name "Star Girtab" occurs in the inner circle of Marchesvan (8th month); this has the number 70 adjoining, and apparently characterising the line which would separate it from the compartment of the 7th month. Now there are various reasons which cause us to identify the 8th month with the sign of the Scorpion. In the first place, there is a general correspondence between the months and the signs of our Zodiac, which long ago led to this result. In fact, G. Smith already indicated that this compartment corresponded with the sign of the Scorpion (*Assyrian Discoveries*, p. 407.† We shall return to the general question of the signs of the Zodiac). But since this was pointed out by Smith, evidence of an independent nature has been found by Dr. Oppert, which makes it certain that the word Girtab means "scorpion." There is therefore a high probability that, by assuming the constellation of the Scorpion to be situated in this compartment, and completing the list of stars in the neighbourhood of the ecliptic according to the longitudes thus indicated, we shall learn what it was about the correspondence of the stars with the months that the makers of this planisphere desired to teach.

To compare the longitudes of the planisphere with our own, we have the following Table, taking the numbers of the inner circle, i.e. the division of 120:—

* The planisphere, as well as Planisphere A hereafter mentioned, is of the nature of a projection of the sky on a transparent plane held between it and the eye. To compare its positions with those of the sky it must be looked at while held overhead, face downwards, as if looking through it at the sky. This is easily seen from the sequence of the months on the fragment. The planispheres are, shortly, "sky aspect." The "globe aspect" is got by tracing a copy of the planisphere through on the back of the paper.

† The true phonetic reading of "Girtab" was not known to Smith. He writes the word "Addil."

		Inner Circle.	Longitudes from same zero, with 360°, reckoned positively.
			°
		20	300
Nisan	1		
		10	330
Iyyar	2		
		120	360
Sivan	3		
		110	30
Tammuz	4		
		100	60
Ab	5		
		90	90
Elul	6		
		80	120
Tisri	7		
		70	150
Marchesvan	8		
		60	180
Cislev	9		
		50	210
Tebet	10		
		40	240
Sebat	11		
		30	270
Adar	12		
		20	300

N.B. The months of this Table are mean months, and do not strictly correspond to the lunar months. But it is in this way that the planisphere must have been made out.

We will now show that, if *Scorpio* be placed in the middle of Marchesvan (between the longitudes 150° and 180° of the 360° set), *Capella* is very nearly in the zero of longitude.

Longitudes from *Regulus*.

	°	′	″	
α *Scorpii*	99	55	15	
β *Scorpii*	93	20	48	
	193	16	3	
Mean	96	38	1	
	360			
	456	38	1	
Capella	292	0	40	
	164	37	21	= mean longitude of α, β *Scorpii* from *Capella*.
	165			= middle of division enclosed by 150° and 180°.

Hence we draw the remarkable conclusion: For the purposes of this planisphere we may take the longitude of *Capella* as the zero of longitude.

This conclusion is entirely independent of our identification of *Capella* as the guiding star of the Babylonian Calendar.

With respect to the other names on the fragment nothing certain is as yet known. We may have to come back to them; and we shall then know that Ligbat may have some reference to the neighbourhood of the Scorpion, and Nibatanu (supposed to be a name of *Mars*) and Utucagabba may have some reference to the neighbourhood of *Sagittarius*.

We have now to see what may be learned from this fragment as to the correspondence between the stars and the months.

We have assumed so far tacitly that the numbers refer to longitudes. It is difficult ts see what other mode of measurement is to be preferred as representing the course of the stars with reference to the months; and we now assume explicitly that the numbers refer to distances measured in the manner of longitudes.

Having the origin of longitude, we can of course lay down the positions of the stars with respect to this origin. The following list shows the positions of a few stars not very far from the ecliptic as they would have been on the completed planisphere. The longitudes with respect to *Capella* are founded partly on Delambre's longitudes from *Regulus*,* checked by various means. The printing of this part of Delambre's work is very inaccurate; and some caution was found necessary in accepting his values. A few of the numbers are taken from Flamsteed's Catalogue in the *Historia Cœlestis*.

* *Hist. Astr. Anc.*, ii., 291.

LONGITUDES OF STARS ARRANGED IN MANNER OF FRAGMENT OF PLANISPHERE.

	Inner Circle.	Long. from same origin in degrees of 360°.	Stars.				
	°	°	°	′	″		
	20	300					
			307	30	42	α Piscium	
Nisan			315	48	11	α Arietis	
	10	330					
						Pleiades	
			340	14	4	α Persei	
Iyyar			347	55	53	Aldebaran	
			[355	0	25	β Orionis]	
			[359	6		γ Orionis]	
	120	360	[			*CAPELLA*]	
			[6	54	6	α Orionis]	
			17	14	50	γ Geminorum	
Sivan			[22	16	23	Sirius]	
			28	23	41	α Geminorum	
	110	30					
			31	44	6	β Geminorum	
Tammuz			[33	58	20	Procyon]	
	100	60					
			67	59	20	Regulus	
Ab			89	27	1	β Leonis	
	90	90					
Elul							
	80	120					
			121	59	6	α Virginis (Spica)	
			[122	22	54	Arcturus]	
Tisri			143	14	0	α Libræ	
			147	30	12	β Libræ	
	70	150					
			161	20	8	β Scorpii	Fragment
Marchesvan			167	54	35	α Scorpii	
	60	180					
Cislev			[203	26	45	α Lyræ]	
	50	210					
Tebet			[219	53	9	α Aquilæ]	
	40	240					
			251	30	11	α Aquarii	
Sebat			[251	58	40	Fomalhaut]	
	30	270	266	44	15	β Piscium	
Adar							
	20	300					

The above list includes only a few principal stars, mostly on or near the ecliptic. As questions arise regarding the stars at a distance from the ecliptic, we have mentioned a few chief ones and marked them with brackets—[ ].

We can now obtain the explanation of the curious arrangement which places the origin of longitude between the 2nd and 3rd months. It arises from the north latitude of *Capella*, which, as we have already seen, causes it to rise heliacally before the foot of its longitude circle. So that, although this star is in this first instance prominently connected with the beginning of the year, yet the system of celestial measurement of which it is the origin would bring it into the list later.

This difference does not, however, account for the whole two months. If in the figure of the morning position of *Capella* in our previous communication we calculate the distance along the ecliptic, from the foot of the longitude circle through *Capella* to the horizon, we have :—

Inclination of ecliptic to vertical = 55° nearly.
Latitude of *Capella* = 23 „

Whence, distance along ecliptic = 37° 19′ nearly ; and this is approximately the difference in the times of rising of *Capella* and the corresponding point on the ecliptic—*i.e.* about a mean month and a quarter. There remain, therefore, about three weeks to be accounted for, if we suppose *Capella* to have risen strictly at the beginning of the year. This, however, was certainly not the case.

The oscillation of date arising from the intercalary months would prevent the existence of any such fixed rule; and it is enough to satisfy the rules of the inscriptions that *Capella* should rise in Nisan, which this arrangement secures.

Further, we cannot certainly tell to what month the writers of the planisphere would have ascribed *Capella*, or the star *Icu*, with which we identify it. But since this star is spoken of elsewhere as characterising the beginning of the year, or the month Nisan, we infer generally that it would probably not appear in the place where it is inserted in brackets in the list, but rather in connection with Nisan.

At the same time there is no difficulty about *Scorpio*, which is on the ecliptic, being placed in correspondence with its longitude.

The only possible explanation of the planisphere is then, that the stars of a month are those which rise heliacally at a period depending on the month.

We can obtain some information as to the period of the mean month at which the rising of stars of the month took place, by examining the case of *Scorpio*, which has been identified on the planisphere, and may be taken to be on the ecliptic.

We have seen that the mean longitude of α, β *Scorpio* from *Capella* is approximately $164\frac{1}{2}°$.

The longitude of *Capella* at the early date (Babylonian, B.C. 2120) is $24\frac{1}{2}°$.

Therefore,

Longitude of *Scorpio*, early date, from equinox = 189° nearly.

Therefore,

Allowing 15° of ecliptic for heliacal rising, position of Sun at rising of *Scorpio* } = 204° long. from eq.

= 6 signs 24°.

Longitude of Sun, 1 Nisan mean year = $-5\frac{1}{2}°$

6 signs $29\frac{1}{2}°$

Or the mean distance traversed by the Sun from the beginning of the year to the rising of *Scorpio* is 7 signs nearly. But *Scorpio* is ascribed to the 8th month.

Hence, if we assume the early date for the planisphere, the meaning of "star of a month," in the case of *Scorpio* at least, would be, that the star would rise at the beginning of the month in the mean year; or that the star would begin to be prominent before daylight during the month—a very natural and intelligible way for the stars to be connected with the months in the first instance.

We can hardly doubt that the stars must have been connected with the months in the period of the early astronomy; and this connection once established is likely to have been handed down, as, in fact, we know that it has been in later times, with a varied meaning; the original phenomena ceasing to appear in the same way, through the influence of precession.

It will not therefore impair the probability of this explanation if doubts arise as to the date of the planisphere in question.

It is not improbable, judging from the character of some of the writing on the planisphere, that it is of a later date than the early period mentioned; and that the archaisms, which strike one at first as evidences of antiquity, were introduced purposely, as is not unusual in the compilation of the astronomical documents. The names both of the months and of the stars on this planisphere are Accadian. There is a quantity of writing on the back of the fragment which is too incomplete to be of any use, but appears to have been a list of correspondences of stars with the Moon. This is Semitic. The colophon refers to "Merodach-mubasa the scribe." The son of Merodach-mubasa was Nebo-zukup-yucin, mentioned in *Trans. Bibl. Arch.*, iii., page 315 (where the translation should be: "According to

the papyri of the old* tablets of Babylon. By Nebo-zukup-yucin the son of Merodach-mubasa the astronomer"). It seems most probable that these two persons lived in the 7th century B.C.; but this is uncertain, and they may have belonged to an earlier period.

If we select the latest date admissible, and refer the planisphere to the time of Assurbanipal, we have to interpret somewhat differently the association between the stars and the months.

We have seen that the equinox still fell about the beginning of Nisan; and we shall assume that the mean position of the Sun on 1 Nisan is unaltered. This is in the absence of more definite information than is given us by the two known equinox inscriptions. The longitudes of the stars were all increased by about $20\frac{1}{2}°$, which has to be added to the previous result. So that the mean distance traversed by the Sun from the beginning of the year to the rising of *Scorpio* (later date, 650 B.C.) is 7 signs 20° nearly; and the rising of a star belonging to a month would generally take place during the month itself.

It is easy to see how the vague notion of "Stars of a month" would admit of the transformation from the one meaning to the other. And whatever date we assign to the planisphere within the historical limits, it does not fail to illustrate an intelligible notion lying between these two extremes.

In this discussion we have thought it unnecessary to take into account the ellipticity of the Earth's orbit, as the terms introduced thereby are not sufficiently large to be of importance in the present stage of the subject.

One more point may be conveniently spoken of here. The Accadian name of the month Marchesvan means "Opposite to the Foundation."

If we suppose the planisphere reconstructed, Marchesvan would be opposite to Iyyar, the second month. There is reason to think that, at the remote period when the Accadian names came into use, Iyyar may have been the beginning of the year. Iyyar was the month of the Bull. The name as ordinarily written is "The Bull the Director," and it is very commonly indicated by the ideograph of "Bull," written alone. There is also an expression "the path of the Sun," which occurs several times in the old tablets. It is impossible to interpret this otherwise than as the ecliptic. So that, although doubtless the ecliptic would first be recognised as the path of the Moon and planets, yet it was, even in very early times, identified with the path of the Sun. And this expression, the path of the Sun, was in many ways identified with "Bull."

For instance, the name commonly ascribed to *Jupiter* is Lubat Guttav. Lubat is planet, literally "old sheep." Guttav is

* The word here translated "old" has that meaning if Semitic; but it is more probably Accadian. In that case it means "in parallel columns," "bilingual."

literally "Bull of the Sun," or "Bull of heaven." Guttav is also explained in an Assyrian gloss by words interpreted by Dr. Oppert to mean "furrow of heaven." Thus the great planet was "the old sheep of the furrow of heaven," Bull being put for the furrow it ploughed. Again we have, "The Bull of Heaven . . . rising . . . in the path of the Sun." (*Trans. Bibl. Arch.*, iii., 187.) Thus the idea of the ecliptic was intimately connected with "Bull." When therefore we find the month Iyyar called "The Bull the Director," and commonly denoted by the symbol "Bull" (which also refers to the stars of that month, according to the name they still bear), it is natural to conclude that the month may have been connected with the beginning of the yearly course of the ecliptic; more especially as the two did certainly correspond at a period more remote than any of which we have direct traces. The month Iyyar being that of the ancient Foundation, or beginning of the year, the Accadian name of Marchesvan, "opposite to the Foundation," would be explained. (*See* the use of the word "Foundation" in Planisphere A.)

If we assumed that the numerical reckoning of the planisphere was itself of ancient date, it might be possible to force an interpretation of Marchesvan as "opposite to the Foundation," by making reference to our zero of longitude. But it is, on the whole, improbable that the numerical reckoning is of very ancient date; and it is more reasonable to suppose that the word "Foundation," in its employment with reference to *Capella*, the zero of longitude and the starting-point of the calendar, was originally derived from an origin connected with the beginning of the year in the most ancient Accadian period.

The agricultural metaphors here alluded to run through much of the Babylonian astronomy, and we shall find further traces of them.

	Accadian Value.	Assyrian Value.	Meanings.
α	an	ilu	god, star.
β	nitakh	nisu	man.
γ	en	bel	bond (?), lord, sky.
δ	bat		opening, omen, corpse, old, to die, sky, channel.
ε	kas		two, double, road.
ζ	alu, *or* zu (uncertain)		city, *or* zodiacal sign.
η	χi		good, knee, multitude.
θ	me		sign for 100.
κ	mat, kur, sat		country, mountain, conquer, be in the ascendant.
	hu		cubit.
	ana		number.

Walker & Co Lith. London

Accadian Value.	Meanings.
gar, sa	to make, four.
khar	circle, centre, body.
X	setting (of the Sun), a foot, &c. &c.
du	to go, advance (as in table of lunar longitudes).
bur	heap.
pa	wing, stalk, dawn.
tar	to cut, place, descend, canal, before.
na	sky, front, chieftain.

Planisphere A.*

This planisphere is a circle divided by radial lines into eight equal parts. Unfortunately large portions of it are missing. We have attempted to represent it in Fig. 2. It is covered with cuneiform characters. We have indicated the translation of some of these, placing the words as nearly as possible in the position of the originals; others we have transliterated; others, which recur in a manner which suggests measurement, we have for the most part represented by Greek characters which refer to notes. We are not able to indicate with certainty the meaning of any of the characters of the last two classes as they occur on the planisphere, though they are mostly characters of ordinary employment in other senses; but see P.S. They appear here to bear some technical meaning. Some inferences can be drawn from the collocation.

We have come to the conclusion that, wherever stars are represented in this planisphere, it is by their names only; not by points or diagrams. The points and diagrams, many of which exist on the planisphere, we believe to possess only interpretational significance. We shall endeavour to show that one figure represents the mechanism by which the lunar beginning of the year was worked out with reference to *Icu*, or *Dilgan* (*Capella*). The other figures we are unable to interpret; but think it extremely probable, for many reasons, that they may have been of an astrological character.

The name of the star *Dilgan*, written in Accadian along the side of one of the figures, gives its locality in the sky. The name, "Star of the Foundation," is written under the name *Dilgan*, the main line of the figure passing between. We interpret "Star of Foundation" as an epithet applied to *Dilgan*, the meaning of which is obvious from our point of view.

The figure, whose principal line passes between these two

* Exact facsimiles of this and the preceding fragment are about to be published by the Society of Biblical Archæology. This planisphere is in Collection K, British Museum; it is not at present numbered.

names, is terminated by two triangular points; the one pointing to the centre of the planisphere, the other pointing outwards. The principal line is not in the straight line joining the vertices of the triangles, but is a broken line, lying mostly to one side. Nearly in the direction which joins the vertices of the two triangles there is a line of seven small circles. On the side of these circles, opposite to the words and line already mentioned, there is written, "Bel that goes before the star." The language of this is Semitic. The head of the triangle which points to the centre of the planisphere is injured, but close to the point four more small circles are clear.

There can be no doubt that this enigmatical figure is susceptible of a simple explanation, on the assumption that it represents the working of the Moon rule for the beginning of the calendar, which was explained in our former communication.

The star *Dilgan* is the star of the rule, whether it be *Capella* or not; so that this application does not depend on our fundamental identification. (*Dilgan* is identified with the "star of stars" of the rule by a passage in an unpublished tablet, which makes "the star of stars" equivalent to "the star *Dilgan* of Babylon.")

The figure having two triangles for its extremities is like a scale, or a rule; the triangles remind one of the arrowheads still frequently employed to mark the terminal points of a scale.

The small circles appear to be the marks on the scale. There are eleven small circles altogether. We cannot fail to notice that there are eleven principal cases of the position of the Moon regarded as parallel to *Dilgan* on 3 Nisan in the working of the rule before explained. If we look at the table of the cases in our previous communication (*Monthly Notices*, xxxix., p. 458), we find the cases in question marked with the letters I. D. (intercalary due), and we verify that there are generally eleven such cases, according to the approximate rule employed. This point is so far one of elementary arithmetic, that we cannot regard it as out of the reach of the makers of the planisphere; we know, indeed, from their tables of squares and cubes, that their command of arithmetic was considerable.

The cases marked I. D. in the table have distances of the Moon from the starting-point, ranging from 3° below to 7° above. This corresponds very fairly with the figure, in which the line of the seven lowest circles is nearly coterminal with the words "Star *Dilgan*," so that the middle of the words corresponds to about the fourth circle from the bottom. The four remaining circles are placed together higher up. From the considerations alluded to at the end of our former paper, and others, it is obvious that any attempt at great accuracy here must be futile. But the general success of the explanation hardly admits of doubt.

We have so far assumed that the planisphere represents *Dilgan* in the western sky at the beginning of the year, on account of the correspondence of the figure with the calendar

rule. But it admits of direct demonstration, by means of the star *Sibzianna*, which is on the planisphere, that the planisphere represents the configuration with *Dilgan* in the western sky, and not in the eastern. Also the sentence, "Bel that goes before the star," can only be interpreted, "The middle of the month before the beginning of the year," since "Bel" was the Moon from the tenth to the fifteenth day.

Sibzianna is mentioned in several passages. It is identified with *Regulus* by Dr. Oppert. We do not admit this identification, but postpone the complete discussion of it. The following passage is sufficient for our present purpose. Inscription of supposed date of Assurbanipal (B.C. 650)—*W. A. I.*, iii., 51, 9, lines 13–19; *Soc. Bibl. Arch.*, iii., 235—"During the month Tammuz current . . . . During the period when the Moon is Anu, in the orbit (region) of *Sibzianna*, it is seen declining." ("Anu" means the first five days of the month. *Vide supra.*)

Examining the consequences of this, we have the following numbers. (λ = longitude.)

Beginning of mean year. (See *Monthly Notices*, xxxix., 459.)

☉'s λ from *Capella*, 1 Nisan	=	-30° (early period).

Assume that at the later period the Sun's position with respect to the equinox is substantially the same (*Equinox Inscriptions, vide supra*). But at the later period we have

Increase of λ of *Capella* from equinox	=	20° (later period).
☉'s λ from *Capella*, 1 Nisan	=	-50 (later period).
3 months' ☉'s journey in λ	=	90
☉'s λ from *Capella*, 1 Tammuz	=	40 (later period).
New Moon's λ from Sun, in mean	=	15
New Moon's λ from *Capella*, 1 Tammuz	=	55
Moon's journey, 4 days	=	52
Moon's λ from *Capella*, 5 Tammuz	=	107

This would give a range of longitude from 55° to 107° for the region of *Sibzianna*, in which the Moon was. But to this must be added the extension of limits in each direction due to variations from the mean values we have employed. The oscillation due to the intercalary months is fifteen days each way—say 15° in the Sun's longitude, and the uncertainty from the appearing of the new Moon may amount almost to a day each way of the

Moon's journey, or 13°. The combined effect of these extends the limit of possible cases each way by 28°; so that the region is defined by the extreme limits of longitude from *Capella*, 27°–135°.

Now, if we assume *Dilgan* in the planisphere to be *Capella* in the western sky, a region 27°–135° in longitude from it will stretch over to the opposite side of the planisphere, and include the place where *Sibzianna* is marked. But if we assume *Dilgan* to be *Capella* in the eastern sky, the region 27°–135° in longitude from it should lie entirely, or almost entirely, below the horizon; and if any part of the region were on the planisphere, it would be close to the edge, between the edge and "*Dilgan.*" This does not correspond at all with the actual position of *Sibzianna.* We infer that the configuration is that of *Dilgan* or *Capella* in the western sky, at the beginning of the year. (*See* P.S.)

The position of the planisphere with reference to the sky is now determined. Holding it overhead, the radial line between *Dilgan* and the Tammuz figure is due west. The equinoxes of the earlier period are near the rim of the planisphere; and the summer solstice is near the centre of the planisphere.

It is at once seen that *Sibzianna* cannot be *Regulus*; for *Regulus* would be nearly in the centre, or a little to the south, whereas *Sibzianna* is considerably to the north.

Comparing the planisphere thus held with the globe on which the stars have been laid down referred to the equator and ecliptic of the globe as equator and ecliptic of the period, we have inferred that *Sibzianna* on the planisphere corresponds with *Arcturus.* The position of *Arcturus* with respect to *Capella* is:—

	Long. from *Capella*,	Lat.
	°	°
Arcturus	$122\frac{1}{2}$	31 N.

The longitude lies within the limits of the observation above discussed. As to the planisphere, assuming the position of the sky above indicated, the longitude of *Arcturus* from the equinox is $24\frac{1}{2}° + 122\frac{1}{2}° = 147°$; or, the distance of *Arcturus* from the summer solstice is about 57° in longitude. Both this and the latitude correspond fairly with the position of *Sibzianna* on the planisphere; but, owing to the effect of the projection, and the vagueness of the indication of position along the length of the words, the longitude indication of the planisphere is rather indefinite, while the indication of latitude is pretty clear and is decisive.

The meaning of the word "*Sibzianna*" is "Shepherd of the flock of heaven." It is impossible to avoid comparing it with *βοώτης*.

There is considerable difficulty about the meaning of the

lines of the planisphere. We think that the line between *Dilgan* and the Tammuz figure is intended for the ecliptic. The marks all along the line look like the marks of a scale. Those on the west (on the side of *Dilgan*) are imperfect; but on the other side we find the series of twelve marks in three sets of four, which we have denoted by four of each of the letters δ, ϵ, ζ. These would, if continued round, correspond to a division of the circle into 48 parts, and so look as if each letter represented 10 degrees of the 480 division.

But the planisphere has strongly the appearance of referring primarily to the zenith as centre and horizon as circumference. If this were so, we should be driven to admit that the makers of the planisphere disregarded the difference between the circle E. zenith W. and the ecliptic at sunset at the beginning of the year. At Babylon, at the period in question, the two are inclined at an angle of about 9°. This would only be admissible on the supposition that the planisphere was made for astrological purposes, or that it was a very early and inaccurate work. The point is not, however, of prime importance, and we shall continue to assume that the E. W. diameter of the planisphere represents the ecliptic, the centre being the summer solstice.

The Tammuz figure corresponds to the position of *Orion*, as is seen by comparing the globe. We have a list of stars of the month Tammuz, in which the star *Gula* appears. Comparing the globe, we identify it with some probability as *α Orionis* (long. from *Capella* 6° 54′ 6″, lat. 16° 3′ 31″ S.). The three marks κ, one of which is nearly obliterated, but is pretty certain, are just where the three stars of the belt should be. We have no idea of the meaning of the rest of the figure.

Star *Bartabba* means double star. There are three different *Bartabbas*, one of which we shall subsequently identify with *Gemini*. The "*Bartabba* which in the hour of *Sibzianna* is fixed" we take provisionally to be the two stars of the Balance, which are seen on the globe to correspond fairly to this description.

In a further communication we propose to examine a tablet containing observations of *Venus*; to treat of the identification of stars; and deal generally with the evidence as to the astronomical knowledge of the ancient inhabitants of Babylonia.

P.S.—On further consideration the meaning of the singular figure with a pointer, a little N. of E. in planisphere A, is apparent. The mark that indicates sunset is written several times within the figure, and the pointer indicates that the sunset is over at the opposite side, where we have placed the letter W. This is entirely consistent with the preceding exposition.

Meteor Showers. By W. F. Denning, Esq.

Several meteor streams observed at Bristol within the last two years appear to be of such marked intensity as to merit special description, and the following notes may be of some use to those who desire to reobserve the annual returns of the showers referred to. I have selected five positions from the large number of radiant points determined since 1877, as under :—

		α	δ	
I	July 30—Aug. 1	32°	+53°	Max. July 31, 1878.
II	July 27–30	341	−13	Max. July 27–28, 1878-9.
III	August 21–25	291	+60	Max. August 21–23, 1879.
IV	October 14–20	31	+ 9	Max. October 15, 1879.
V	August 8–11	44	+25	Max. August 10?

I. At the middle of July 1877 a few meteors were traced from a radiant point at 36°+47°, and on projecting a large number of meteor tracks registered in foreign catalogues for the period July 25–31, I found the same shower amply manifested from 25 paths, though the radiant was 5° higher in declination. A succession of clear nights occurred from July 26 to August 2 in 1878, and I obtained some lengthy observations. In about 22 hours of watching more than 400 shooting stars were seen in the eastern sky, chiefly amongst the constellations of *Perseus*, *Cassiopeia*, and *Andromeda*. I saw many swift meteors leaving short streaks and otherwise exhibiting much uniformity in their appearances and directions. The radiant was evidently in *Perseus*, and at first I mistook them for early members of the closely approaching Perseids of August 10, but soon found from a number of foreshortened paths that the radiant point was not reconcilable with that of the well-known annual shower. It was sharply defined about 3° S. of the group χ *Persei* and the maximum of the shower was witnessed on the last night of July, when 21 meteors were noted diverging from the same point below χ *Persei*. In all I saw 63 meteors conforming to this stream; they were short and quick, always with streaks of 3° or 4° in the latter portion of their flights. I looked for the shower again in 1879 and recovered it both on July 28 and 29. It appears to be identical with a radiant given by Schmidt at 31°+55°, August 3–12. The diagram shows the observed paths of 86 $\downarrow^s$ (in the region of the radiant point) recorded at Bristol in the years 1877–8 and includes some tracks in the catalogues of foreign observers. Several of the meteors are apparently directed from a point slightly north of the position observed in 1878 and conform to a centre at χ *Persei* precisely ; but I am fully satisfied that the true radiant lies quite 3° below that cluster. There is evidence of a prominent shower at about 32°+57° on

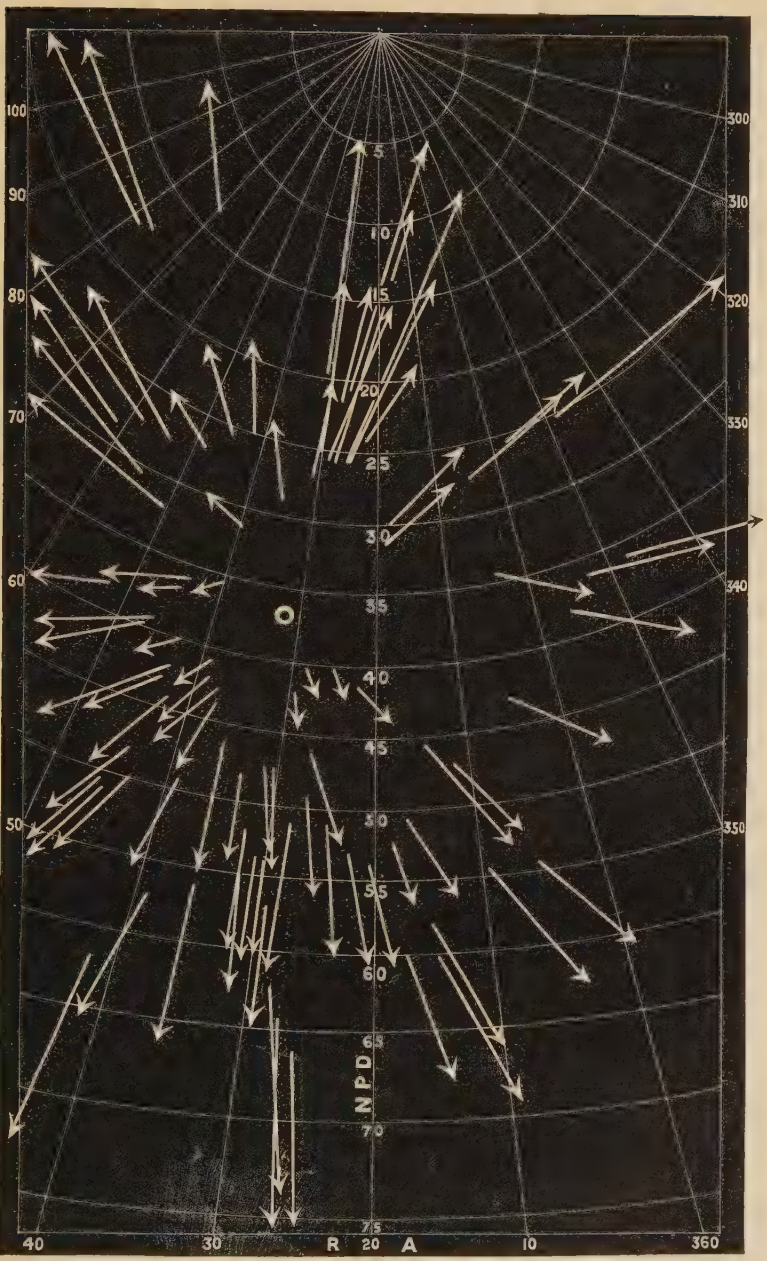

FIG. I.—Shower of χ Perseïds, or Perseïds II, near the radiant point 32°+53°, max. July 28--Aug. 1.

August 10; but that is probably a different stream and one of the principal radiants of the major Perseïds.

II. Contemporary with these χ Perseïds, or Perseïds II, my observations in July 1878 led me to recognise a large number of slow meteors with long paths (averaging 17°) and occasionally leaving faint trails of sparks, ascending amongst the stars of *Pegasus*, *Andromeda*, &c., which, by their parallelism of motion, obviously proceeded from a common radiant point presumably situated at a low altitude and considerably southwards of *Pegasus*. I watched them narrowly, and determined the radiant with fair precision as near δ *Aquarii*. The best display of this fine shower was on July 27, when 22 of its meteors were recorded, but they were also numerous on the few ensuing nights. In the three-quarters of an hour preceding midnight on July 30, eight of these Aquariads were visible, though the radiant was close to the horizon; but on the following night the shower appeared to

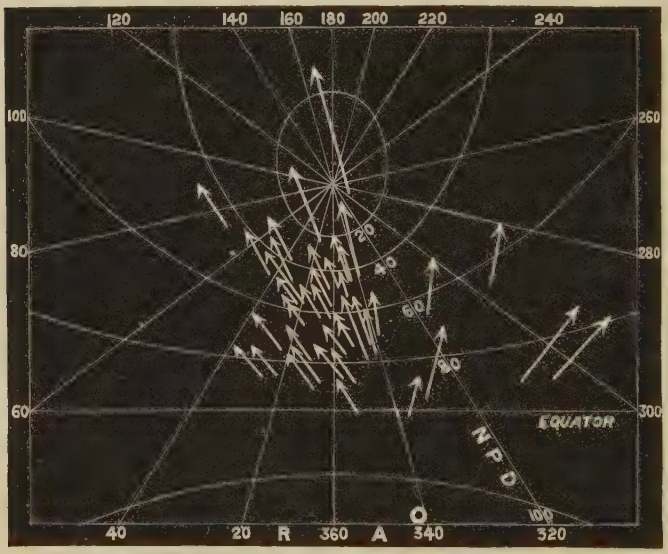

FIG. II.—Shower of Aquariads (341°—13°), max. July 27–30.

have become extinct. In 1879, July 28, it reappeared, giving very long gradual meteors similar to those seen the year before. In a watch of two hours ($11^h\ 45^m$ to $13^h\ 45^m$) on the night mentioned 45 shooting stars were counted, of which 14 were Aquariads diverging from the point 338°—14°. Just before midnight the shower was in active progress, supplying several fine meteors brighter than the stars. The continuation of this radiant in August is rendered extremely probable by my observations in 1877, when I detected a good centre at 342°—12° from twelve meteors,

August 3–16, and by a bright stationary meteor, also recorded at Bristol, on August 9, 1879, at 342°−16°. An observation very similar to the latter was obtained by Sawyer at Cambridgeport, Mass., on August 7, 1879, of a 2nd mag. stationary meteor at 344−°13°, and further proof of the shower's sustenance in August is afforded by several positions of Schmidt and Neumayer :—

	° °	
August 1–12	345− 7	Schmidt.
August 1–31	341−11	Schmidt.
August 1–31	337−10	Neumayer.

Schmidt had also traced the shower in July, for he gives two positions for July 20–31 with a mean = 337°−11°; but Major Tupman had obtained the best previous observations of the shower. On July 27, 1870, and several ensuing nights, he saw many meteors from an accurate radiant at 340°−14°, and the position and epoch of the shower, as he determined it, agree perfectly with its apparition in 1878–79 recorded at Bristol. Prof. Herschel had also, as early as July 28, 1865, traced a few of its meteors. Later showers (of very slow meteors) from the same region of *Aquarius* appear in September and October, and are possibly prolonged into November; for on November 7, 1877, the Rev. S. J. Johnson, at Crediton, saw a 1st mag. meteor stationary at 338°−15°. The diagram shows 41 tracks registered at the end of July, chiefly in 1878, at Bristol.

III. Beginning to observe at about $9^h\ 30^m$ on August 21, 1879, I immediately found that a very active shower of slow trained meteors was proceeding from a point in *Draco*. I noted 9 of them in the $\frac{3}{4}^h$ before $10^h\ 15^m$, though afterwards the shower became less decided, and of the 68 meteors which I counted up to $13^h\ 30^m$ (when clouds overspread the sky) 21 belonged to this system. The two ensuing nights were clear, and I saw 143 shooting stars, including 31 additional paths conforming to the special shower in *Draco*, the exact position of which I determined at 291°+60° (near *o Draconis*). The night of August 24 was overcast; but on the 25th I watched the sky at intervals between large breaks in the clouds and noted several fine meteors from the same radiant point. The total number directed from this stream was 56 out of an aggregate of 225 meteors seen on August 21, 22, 23, and 25. The Draconids were generally brilliant, with short paths and spark-trails; motions rather slow. Ten exceeded or equalled the 1st mag. and 15 were estimated = 2nd mag. The same shower was found by Tupman on August 20–25, 1871, at 280°+58°, and Corder saw it at 286°+61° (10 ↓ˢ) on about August 16, 1879. It is evidently identical with the Draconids II (No. 78) of Greg's *Catalogue of Meteor Showers* (1876), in which the position is averaged at 282°+60° and the whole duration extends from June 28 to August 25 ? from 12 observations. There are other conspicuous showers from the same region near *o Dra-*

conis in April–May, and again in November and early in December, (*see* Greg's Nos. 64 and 166). The diagram gives 41 paths, nearly all of which were traced on August 21–23, 1879. These dates nearly coincide with a fireball epoch (August 19–22), and

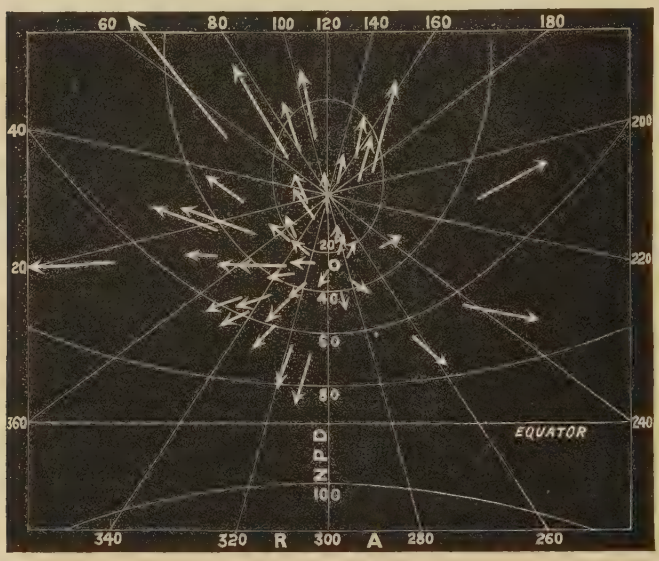

FIG. III.—Shower of Draconids (291°+60°), max. Aug. 21–23.

there is little doubt that the rich shower of Draconids referred to has furnished us (in conjunction with a shower of Cepheïds from near *β Cephei*) with a large proportion of the brilliant meteors observed at this season of the year.

IV. On October 15, 1879, the sky was watched for 11 hours ($6^h\ 30^m$ to $17^h\ 30^m$), and of the 127 shooting stars seen during that long obs rvation, 21 were slow meteors from a radiant point at 31°+9°, but the position was not well defined. I had seen several meteors from the same region on the previous night, and on the 20th, when the sky was again favourable, I recorded 10 others, making 37 in all from this shower in the south of *Aries*. They were generally faint, with rather short paths and decidedly slow. The same radiant was seen by Major Tupman in 1869, October 13, at 28°+10°, and Mr. Corder has distinguished a series of positions in *Aries* and *Pisces*. He remarks that "there are several radiants of small meteors about this place in October, which are difficult to separate." At the middle of October 1879 he determined an active shower at 25°+8° (18 $\downarrow^s$), and, towards the end of the same month, saw a radiant at 32°+11° (10 $\downarrow^s$). Mr. Corder had also witnessed the two preceding apparitions of

the shower, for in 1878, October, he tracked 17 paths from the point 37°+10°, and in 1877, October, found a position at 30°+10° (9 ↓s). These several observations unquestionably refer to one and the same stream, situated approximately between *α Arietis* and *α Piscium*, and nearer the latter star; but there may be a few branch radiants closely adjoining, as suspected by Mr. Corder, and this would explain the apparently diffuse radiation of the

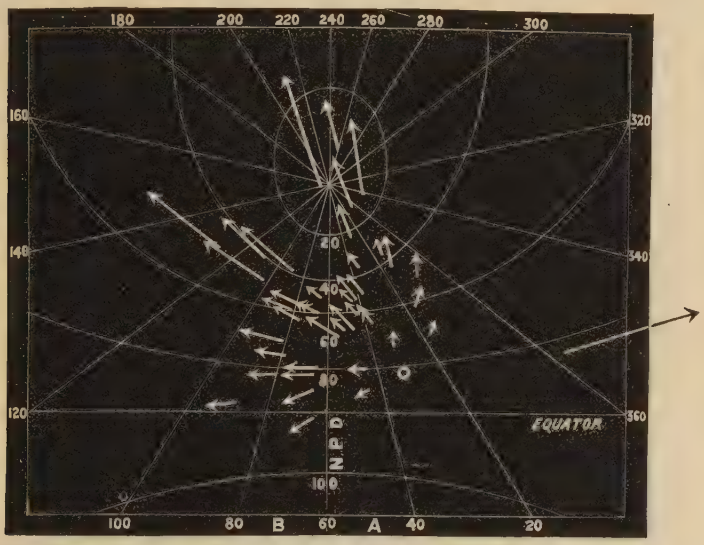

FIG. IV.—Shower of meteors from a radiant point at 31°+9°, Oct. 14–20 (max. Oct. 15).

meteors seen in 1879. The diagram (IV) includes 42 paths observed by me in the years 1876–79, but chiefly in 1879. The meteors were mostly seen amongst the stars of *Perseus* and *Taurus*, which I was watching at the time of the shower's appearance.

V. At about the middle of August 1877, a few rapid meteors were traced from a radiant in *Musca* at 40°+28°, and in the following year, while noting the progress of the Perseïds, I recorded several fine meteors, leaving streaks and with paths averaging 40°. The radiant was evidently on the horizon, and the directions of the meteors, which in several instances were very exactly observed and mapped, indicated the point 44°+25° as the diverging focus of the shower. With the object of further investigating it, I looked through the observations made at the epoch of the Perseïds, by the Italians in 1872 and by Zezioli in 1867–70, and found many meteors conforming to this same shower in *Musca*, which had already been detected by Weiss in 1869, August 11, 46½°+23½°, and August 12, 41½°+24°. Denza also appears to have seen it in 1869, August 10, at 48°+19°.

In this region, between *Musca* and the E. extremity of *Aries*, there are many successive showers during the four months from August to November. I have seen one in September (after the 20th), and again on October 8 and 15, October 31-November 4; and in the present year, on November 12–14, while observations were directed towards the stars of *Leo*, a large number of slow, bright meteors were seen both by myself and Mr. Corder from two very decided radiants of Taurids and Muscids. Early in August, when the first shower from *Musca* is perceptible, the meteors are very swift, with unusually long paths, and seldom without streaks; but in October and November the motions are

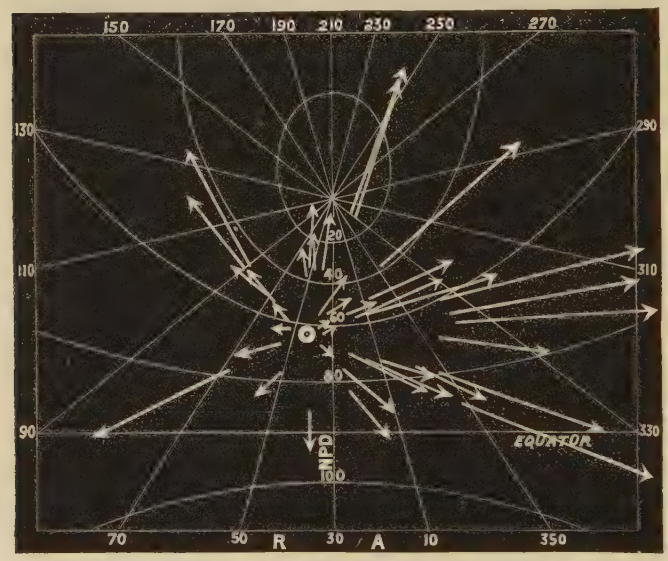

FIG. V.—Shower of Muscids (44°+25°), max. Aug. 8–11.

generally slow, and the phosphorescent streaks, forming so persistent a feature of the earlier displays, have given way to occasional trains of ashy sparks. The August shower above referred to is not perhaps of special intensity, but it merits description as of contemporary occurrence with the Perseïds, and as supplying some fine long meteors in the mornings of August. Thirty-eight paths are shown in the diagram, several of which are notable on account of great length.

The several showers of χ Perseids, Aquariads, &c. here mentioned, being apparently of little less importance than the Orionids, Geminids, Taurids, &c., will no doubt be frequently seen in future years; and it seems desirable to select them from the mass of feeble systems now ascertained, as affording displays of more

than ordinary richness. Many other similar examples of fairly active streams will be found as observations increase, and it will be necessary to single these out for special investigation.

Amongst the radiant points seen at Bristol during the last two years* a few others (in addition to those already specified) have exhibited signs of importance, and the dates and positions of these were as follows :—

	α	δ	↑*	
	°	°		
July 31—August 1	332	+50	14	Lacertids.
July 31—August 1	12	+70	16	
July 31—August 1	321	+31	10	ζ Cygnids.
August 21–23	319	+30	12	
August 1–2	291	+70	14	δ Draconids.
July 26—August 1	28	+36	12	Triangulids.
September 14–25	30	+36	16	
July 25–26	332	+37	11	
August 21–23	46	+47	9	α Perseïds.
September 14–25	99	+43	15	Lyncids.
October 14–20	95	+46	11	
September 21	31	+19	10	Arietids.
September 14–25	76	+32	17	Aurigids.
October 14–15	77	+57	19	
October 15	106	+23	11	Gemellids.
October 4–20	316	+59	17	α Cepheïds.

In each case the radiant may be regarded as accurate.

At the middle of September 1879 a shower was seen from α *Aurigæ*, and in July, September, October, and November many meteors have fallen from an exact centre 3° S. of α *Cassiopeiæ*.

Meteor Showers, 1870–1879. By Henry Corder, Esq.

(*Communicated by W. F. Denning, Esq.*)

The accompanying meteor radiant points have been culled from a list of about 230, chiefly observed between the years 1876–1879, the total number of meteors registered since 1870 being about 5,800, but of this time only the last three years have been made of much real use.

In mapping the meteors, rough star charts copied from an

* The results obtained up to the end of 1877 have already appeared in the *Monthly Notices*. See vol. xxxvi., pp. 283–89; vol. xxxvii., pp. 105–15; and vol. xxxviii., pp. 303–14.

atlas have been used out of doors, and the tracks afterwards laid down on tracing paper over the star charts of the British Association.

In observing the direction of a meteor's path the eye unconsciously prolongs it backwards or forwards to some bright star, and it is therefore found that a ruler held up as near as possible parallel with the track, especially if a streak is left, is a great help in mapping.

The time of watching has generally been from dark till 12 or 1, but occasionally morning watches have been made. Meteors are then more numerous, and the swift streak-leaving class in the best position for observation.

It has lately been found advisable to register all shooting stars in three classes:—

Class 1. The swift streak-leaving meteors.

Class 2. Slow meteors with trains.

Class 3. Small, quick meteors, with short paths, occasionally streak-leaving.

As types, may be selected:—

Class 1. Perseïds, Leonids, Lyrids, Orionids.

Class 2. Andromedes, Taurids I.

Class 3. Geminids.

Out of this year's total of 1,463 meteors (1879), the swift class took 43 per cent., the slow 17 per cent., and the remainder (40 per cent.) were of the small quick class.

The difference in the classes is exemplified by the number of streaks and trains.

Class 1. 63 streaks, 0 trains per cent.

Class 2. 2 ,, 30 ,, ,,

Class 3. 2 ,, 0 ,, ,,

The fireballs in either class may differ rather from the above. Swift streak-leaving fireballs may have a short train of sparks; and occasionally slow-trained meteors, Taurids for instance, leave narrow streaks; but as a rule these divisions hold good, and it is rarely difficult to tell in which a meteor should be placed. In mapping also they are kept distinct to prevent the chance of adding swift meteors to a radiant of slow ones, or *vice versâ*. Not unfrequently there are two radiants close together, and both active at about the same date. A good example was afforded in December 1877. The Geminids, of Class 3, were preceded by, and partly contemporaneous with, a shower of fine swift meteors,

Class 1. This latter radiant (No. 93 in the list) was extremely well defined when its long streak-leaving meteors were sifted out from the short insignificant ones radiating from a few degrees north.

As to colour in meteors, hardly enough have been seen yet to classify them sufficiently well to be of much interest.

About 10 per cent. of all the shooting stars show a distinct colour, the most usual being orange or red. The Taurids and other slow-moving meteors *seem* rarely to get warmed above a red heat; the large ones, or those going a long way, often turn from orange to bluish white like burning magnesium; sometimes the change is very sudden and startling.

Green is a tolerably common colour, especially in slow-moving fireballs about equal to *Venus* in lustre; they generally have a short train of red sparks.

A purple or mauve tint, like that given by copper, is occasionally noticeable.

The following notes have been made on some of the principal showers:—

Lyrids.—Usually white; some pale yellow. A pale green fireball probably also belonged.

Perseïds.—Characterised by deep orange in meteors equal to *Sirius* or *Jupiter*; in smaller 1st mags. yellow; in larger ones a pale green, the meteor suddenly bursting out into a flash like lightning, and leaving a reddish streak. About 20 per cent. show colour.

Orionids.—Not 10 per cent. coloured. First mags. are very rare, and are yellow. The rest white.

Leonids.—Streaks green, meteors yellow; but very few have been seen by the writer.

Andromedes.—A large number orange; also seldom observed.

Taurids.—Over 20 per cent. coloured, usually orange and red, but 1st mags. pale yellow-green, with faint red streaks.

Geminids.—Only 5 per cent. coloured. First mags. rare, generally primrose or white, but the larger ones emerald. One in 1879, deep orange red, was possibly a Geminid.

Geminorum.—The shower mentioned above as being almost contemporaneous with the Geminids. Two large meteors in 1877 were purple-mauve in colour.

Writtle, near Chelmsford,
1879, *December.*

List of Radiant Points of Meteors observed in 1876-9 *by H. Corder, Writtle, Essex.*

Class 1 = swift, streak-leaving meteors.

Class 2 = slow, trained meteors.

Class 3 = commonplace, short meteors, which rarely have streaks.

No.	Date.	R.A. °	Dec. °	Position or Name.	Remarks.	Class.	No. of ↓[3]
1	Jan., middle	92	+43	Auriga	A few seen each year.	3	15
2	,,	55	+35	Perseus	Fine meteors; not many seen 1877.	2	
3	Dec.—Jan.	130	+53	θ–ι Ursæ Maj.	Three positions averaged.	1	
4	Jan.	70	+26	Taurids III		2	3
5	Jan.–Feb.	128	+27	ι Cancri	Regular, but feeble.	1	10
6	Feb.—March	172	+62	Ursa Major	In 1877 only.	3	8
7	,,	156	+26	Leo Minor	,, ,,	3?	10
8	Feb.—April?	98	+37	θ Geminorum	Orange slow-trained meteors.	2	8
9	March	262	0	Ophiuchus	Fine long streaks.	1	3
10	,,	280	+65	Draco	Ill-defined position.	3	10
11	,,	247	+ 1	Serpens	Principal position out of several adjoining.	3	10
12	,,	232	+26	Corona	Small.	3	12
13	March—April	233	+11	Serpens		3	12
14	,,	200	+55	ζ Ursæ	Small, short meteors.	3	10
15	,,	210	+23	Arcturus		3	6
16	March	180	− 2	Virgo		2?	7
17	April	210	− 7	,,	Long continued in 1877.	2	10

18	,,	245 + 55	Quadrans	Badly observed.	1	—
19	,,	312 + 21	Cygnus		2	6
20	April 18–21	275 + 36	Lyrids	Generally white, fairly long meteors; larger ones yellow.	1	50
21	April	174 + 7	Virgo	Nearly all 4th mag.; long continued.	2 or 3	26
22	,,	190 + 20	Coma		3	5
23	April—May	334 − 5	Aquariads	Fine long meteors at daybreak.	1	6
24	,,	300 + 20	Sagitta		1	7
25	May	221 + 1	Virgo		2	5
26	,,	227 − 8	,,	Possibly the same shower.	2	9
27	,,	273 + 55	Draco		3	12
28	June	197 + 45	Canum	Very short; seen at same spot (192 + 38) in March.	3	10
29	,,	240 + 73	γ Ursæ Minoris		3	8
30	,,	320 + 56	Cepheïds	Well seen in 1877, but not much since.	1	14
31	,,	260 − 4	Ophiuchus		2	?8
32	May—Aug.	19 + 57 20 + 60	Cassiopeïds	Almost the same position, but must be distinct showers; always seen in August.	1	40
33	July &c.	333 + 12	Pegasids	Very diffuse; probably two positions.	1	13
34	,,	332 + 48	Lacertids	,, ,, ,,	3	8
35	,,	300 + 8	Aquilids	No defined position seen.	3	12?
36	,,	6 + 40σ	Andromeda		1	4
37	July—August	295 + 55	Cygnids?	Two green meteors = *Jupiter* &c	2	4
38	,,	337 − 13	Aquariads	Fine long meteors.	2	5

No.	Date.	R.A.	Dec.	Position or Name.	Remarks.	Class.	No. of ↓
39	August	44	+56	Perseïds	Largest meteors pale green; others orange &c.	1	910
40	July—August	39	+52	,,	Several positions before the true Perseïds.	1	
41	August 17 &c.	307	+65	Cepheus.	Regular shower.	1	18
42	,,	304	+58	,,	Slow meteors.	2	7
43	,,	298	+55	,,	Small quick meteors.	3	7
44	,,	335	+69	,,		3	7
45	,,	320	+22	*f* Pegasi		1	9
46	,,	23	+72	Custos	Also 30° + 64° and 45° + 70°, doubtful.	3	11
47	August	62	+48	μ Persei	Many other indistinct positions seen every year about the end of August.	1	46
48	,, end	53	+44	ν Persei		1	
49	August—Sept.	3	+7	Pegasus	Seen in two years.	3	12
50	,,	332	0	Aquariads	Slow, orange mets.; difficult position to distinguish.	2	12
51	,,	351	+4	Piscids		2	34
	,,	3	−2	,,		2	
52	Sept.	30	+40	Triangulum		1	20
53	,, middle	45	+50	Perseus		1	20
54	,,	72	+18	Taurus	All seen in 1877, and scarcely seen since; all of the streak-leaving class.	1	6
55	,,	92	+34	Auriga		1	6
56	,,	80	+30	,,		1	7
57	,,	50	+20	Musca		1	10
58	,,	5	+50	Cassiopeia		3	9

59	,,		294+23	Cygnus		3	7
60	,,		297+50	,,	Much finer meteors than 59.	2	7
61	,,		331+48	Lacertids	Short meteors.	3	14
62	,,		15+16	η Piscium		3	13
63	,,		45+34	β Persei	Fine meteors on one evening (7th 1879).	1	6
64	,,		340+86	Polaris		3	12
65	Oct.		334+15	α Pegasi		3	7
66	,,		320+80	κ–γ Cephei	Fine meteors, slow, but with streaks.	1	9
67	,,		75+45	Aurigids		1	13
68	,,		11+22	Pegasus		3	7
69	,,		20+25	η Andromedæ	Perhaps connected with 68.	3	8
70	,,		30+20	Aries	Fine meteors.	1?	6
71	,,		25+ 8	o Piscium	There are several radiants of small meteors about this place and date difficult to distinguish.	2	60
72	,,		32+11	ξ Ceti		3	
73	,,		23+ 8	o Piscium		3	
74	,,		110+14	Canis Minor		1	9
75	,,		127+54	ι Ursæ Majoris		1	17
76	,,		106+27	Gemellids		1	8
77	,,		32+34	Triangulum		3	13
78	,,	16–22	90+14	Orionids	Fine shower, but augmented by the following two.	1	164
79	,,	,,	88+24	η Geminorum	Very few large ones, but many streaks; possibly all connected.	1	
80	,,	,,	93+19	ν Geminorum		1	

M

No.	Date.	R.A. °	Dec. °	Position or Name.	Remarks.	Class.	No. of ↓ⁿ
81	Oct. 27	102	+19	ζ–γ Geminorum	Very swift; many streaks.	1	16
82	,, 9–22	95	+34	θ Geminorum	Chiefly on Oct. 9, but more on 22nd? (distinct).	1	10
83	,,	306	+64	Cepheus	Poorly marked.	3	10
84	Oct.—Nov.	43	+15	f Tauri	Small meteors preceding true Taurids.	3	34
85	,,	45	+47	Perseus	White, small meteors, long continued.	3	34
86	,,	41	+13	Aries		3	13
87	,,	51	+ 7	o Tauri		1	14
88	Nov.	59	+20	Taurids	Always interesting; slow meteors.	2	195
89	,,	148	+25	Leonids	Not properly mapped till 1879.	1	30
90	,, 27 &c.	23	+44	Andromedes	Only a few seen.	2	30
91	,,	140	+40	Ursites	Average of a number of vague positions.	1	30
92	,,	205	+68	α Draconis		3	9
93	Dec. 9 &c.	108	+28	ι Geminorum	Fine long meteors; very different to 94.	1	20
94	,, 10–13	107	+35	Geminids	Larger ones, pale green; very few streaks.	3	206
95	,,	78	+23	Taurids II		2	20

The November Meteors. By the Rev. S. J. Perry.

The utility of acquiring as complete a knowledge as possible of every detail respecting the important meteor stream that radiates in November from the Lion has induced me to keep up an annual watch from 10 P.M. till sunrise on every night that offers any chance of observation from the 12th to the 16th. The weather of late years has been generally unfavourable; but this year the sky was perfectly cloudless, and this, with the absence of the Moon, presented an opportunity not often met with at this season of the year. On the morning of the 13th only one observer was employed; but during the remainder of the time two observers were stationed facing the N.E., and the watch was uninterrupted from 10 P.M. till sunrise on the 13th, 14th, and 15th.

	Total No. of Meteors.	Mag. greater than 1st.	1st and 2nd Mags.	3rd and 4th Mags.	5th and 6th Mags.
Nov. 13	67	2	25	31	9
„ 14	144	4	39	45	51
„ 15	98	4	31	28	27

The paths of nearly all the meteors could be accurately noted, and the following was the proportion that radiated from the Lion:—

	Number.	Mag. greater than 1st.	1st and 2nd.	3rd and 4th.	5th and 6th.
Nov. 13	16	1	2	10	2
„ 14	53	1	11	10	30
„ 15	35	2	14	12	12

The increase on the morning of the 14th was principally due to meteors of the 5th and 6th magnitude, which constituted considerably more than half the total; on the 15th the magnitudes were very equally distributed.

It may be useful to give the paths of the most brilliant meteors for the sake of comparison with other stations.

	G.M.T. h m	From	Towards
Nov. 12	10 36 p.m.	3° below *β Arietis*	*η Ceti.*
„ 13	3 38 a.m.	*δ Leonis*	*Spica.*
	11 8 p.m.	3° left of *Bellatrix*	Midway between *Sirius* and *Procyon.*
„ 14	4 33 a.m.	*λ Leonis*	Head of *Hydra.*
	5 49	*α Hydræ*	S. Horizon.
„ 15	2 24 a.m.	*ξ Hydræ*	5° W. of *α Hydræ.*
	3 39	*μ Orionis*	*β Eridani.*
	4 9	¼ dist. from *λ* to *κ Leonis*	*γ Canis Minoris.*
	4 34	*κ Leonis*	3° N. of *β Canis Min.*

A first magnitude star was observed on the 15th at $1^h\ 34^m$ A.M. perfectly stationary at R.A. 157° 18′, N.P.D. 52° 30′.

The time of the maximum for this year will be best presented in a tabular form:

		Midnight to 1 a.m.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.
Nov. 13	Total meteors	9	9	7	3	6	3
	Leonids	2	4	3	2	4	1
„ 14	Total meteors	12	19	22	17	23	19
	Leonids	7	9	6	7	15	9
„ 15	Total meteors	10	13	18	23	17	
	Leonids	3	7	5	9	8	

This Table shows that the Leonids were fairly distributed throughout the morning of the 15th, and were generally as numerous as on the 14th. The only approach to a maximum was between 4 and 5 A.M. on the 14th. The principal radiant was slightly below the line joining ϵ and ζ *Leonis*, and rather nearer the former star, or at R.A. 147° 20′, N.P.D. 67° 10′. The positions of the secondary radiants were R.A. 166°, N.P.D. 67° 40′ between δ and 72 *Leonis*, and R.A. 155° 12′, N.P.D. 54° 54′ between 31 and 37 *Leonis Minoris*. Few of the meteors had trains, and none were visible for more than 4^s.

A large number of meteors radiated towards a point near *Cor Caroli*.

On the 27th the sky was fairly clear from sunset to midnight, but the Moon very bright. No meteors were seen in the direction of *Andromeda*.

Stonyhurst Observatory,
1879, *Dec.* 6.

Occultation of 64 *Aquarii by Jupiter, observed at the Melbourne Observatory*, September 14, 1879. By R. L. J. Ellery, Esq., Director of the Observatory.

Observed by Mr. Ellery.

Telescope, 8 inches aperture; power 300.

Sky clear and objects steady some time before first contact.

The smallness and faint light of the star as compared with the satellites first attracted attention. The grand colouring of *Jupiter's* belts—one quite purple (with streaks of brick-red in the temperate zones), and the other greenish grey and broad—was remarkable. The star first appeared to touch the planet's limb at $10^h\ 5^m\ 19^s$ M.M.T., and was visible in that position for nearly two minutes, when, while still making a projection on the planet's outline, it all at once appeared as if seen through a mist or haze, *and entirely projected on the planet's limb*. This faded away in about ten seconds, leaving still a decided nipple-like projection on the

edge of the planet, as if the planet itself bulged out, without any signs of the true light of the star; and at $10^h\ 7^m\ 43^s{\cdot}8$ this disappeared, leaving a clean outline to the disk.

The light of the star, although it appeared faint compared to that of the satellites, appeared as a bright speck on the planet's limb when actually in contact with it.

Observed by Mr. E. J. White, with the North Equatoreal, $4\frac{1}{2}$ inches aperture, 5 feet focal length: power 200. Used the full aperture, and a positive eye-piece magnifying 200 times. The time was taken with the sidereal chronometer, Barraud $\frac{2}{861}$, which was compared with the Transit Clock a few minutes after the observation of disappearance, and found to be $1^m\ 4^s{\cdot}0$ slow of Melbourne sidereal time.

The first impression on looking through the telescope was surprise at the small quantity of light of the star as compared with that of the satellites.

Watched the star, which became nearly overpowered by *Jupiter* as it got near the limb, so that the observation was very difficult. Although the definition was very good in a cloudless sky, yet slight oscillations of the planet occurred which made the star momentarily disappear. At $21^h\ 37^m\ 46^s$ by chronometer I thought the star had really disappeared; but on looking again I saw it projecting as a bright nipple on *Jupiter*, which seemed to gradually lessen in size till $21^h\ 39^m\ 13^s$, when I finally lost sight of it. Soon after this the sky became rather hazy, which quite prevented any observation of the reappearance. The above chronometer times correspond to $10^h\ 6^m\ 23^s{\cdot}7$, and $10^h\ 7^m\ 40^s{\cdot}4$ Melbourne mean time.

Observed by Mr. J. Turner, with the Great Melbourne Telescope: power 350.

As the star approached close to the limb of *Jupiter*, the definition (hitherto very unsatisfactory) so improved as to be all that could be desired; the limb of the planet being sharp and steady, thus enabling the contact to be well observed.

At the moment of contact the star did not instantly disappear, but seemed to possess a visible disk, the limb of *Jupiter* seeming to advance gradually upon it, the star by-and-by appearing to be bisected and then gradually disappearing altogether.

The time of final disappearance was $10^h\ 7^m\ 47^s{\cdot}6$ M.M.T., at which instant the circle of *Jupiter's* limb appeared perfect; previous to this the star appeared as a small protuberance upon the limb, which *gradually* got smaller until final disappearance.

The time of first contact was not noted, but I estimated the interval between contact and disappearance at about 35 seconds—certainly not less; it might be more.

For about 10 seconds after disappearance the star could be seen *through Jupiter's* atmosphere as a speck of light seen through ground glass. This also disappeared *gradually*.

There was no fitful disappearance and reappearance, but gradual disappearance throughout.

Reappearance.

About an hour after disappearance clouds set in with occasional narrow breaks.

At $12^h\ 26^m\ 1^s$ got a clear view of planet, but no trace of star visible,

At $12^h\ 34^m\ 47^s$ got another clear view for about 5 seconds, and could clearly see a minute protuberance where the star was expected to appear. This protuberance exactly resembled the one half of the disk-like appearance of the star at disappearance.

At $12^h\ 37^m\ 57^s$ got another view for about 10 seconds, when the star was seen well separated from *Jupiter*. The small protuberance noted 3 minutes previously was thus proved to be the reappearance of the star.

Heavy clouds now set in, compelling closing up.

The times above noted are Melbourne mean time.

Occultations of Stars by the Moon, seen at the Stonyhurst Observatory.

By the Rev. S. J. Perry.

	Phenomenon.	Moon's Limb.	Power.	G.M.T. h	m	s	Observer.	Remarks.
1879. October 5	Disapp. of *k Tauri*	Bright	303	11	18	43·1	S.J.P.	Well seen up to limb.
	Reapp. ,,	Dark	,,	12	23	49·0	,,	Very good.
November 23	Disapp. of 45 *Piscium*	Dark	350	10	49	9·0	W.C.	Instantaneous; sky rather hazy.
,, 27	Disapp. of 9 *Tauri*	Dark, but close to bright	,,	11	36	10·0	S.J.P.	Very good.
,, 30	Disapp. of 5 *Geminorum*	Bright	,,	9	21	41·7	,,	Star indistinct when close to limb.
	Reapp. ,,	Dark	,,	10	17	30·4	,,	Good.

On December 1 44 *Geminorum* was not occulted, although Stonyhurst (lat. 53° 50′ 40″) is just within the required limits.

The above observations were all taken with the 8-inch Equatoreal, and generally a translucent screen was used in the eye-piece, covering rather less than half the field of view.

Observations of Jupiter's Satellites, made at the Stonyhurst Observatory. By the Rev. S. J. Perry.

1879.	Satellite.	Phenomenon.	G.M.T. h	m	s	In excess of *N.A.* m	s	Observer.	Remarks.
June 4	I	Ec. D. last seen	14	28	57·5	+0	17·5	W.C.	Fair, daylight, thin clouds passing.
Sept. 28	,,	Tr. I. external contact	11	55	47·6			,,	Good.
		bisection	11	58	9·7				
		int. contact	12	0	36·6				
	,,	Sh I. int. contact	12	42	17·1			,,	Very poor, faint. Very unsteady.
,, 29	,,	Oc. D. ext. contact	9	12	19·7			,,	Poor, tremulous, ill defined.
		bisection	9	14	5·7				
		last seen	9	16	22·2				
	,,	Ec. R. first seen	12	13	59·4	−1	8·6	,,	Slightly unsteady, but definition very good.
		full light	12	16	29·4				
Oct. 14	,,	Tr. I. bisection	10	0	21·5			,,	Difficult, thin clouds, very tremulous.
		Sh. I. bisection	11	0	41·3			,,	Poor, very tremulous.
		internal contact	11	1	56·4				
		Tr. E. bisection	12	18	52·4			,,	
		external contact	12	21	31·1				
,, 15	,,	Oc. D. external contact	7	11	39·6			,,	
		bisection	7	14	42·6				
		last seen	7	17	9·7				

	I	Ec. R.	first seen	10	34	59·7	−0 8·3	S.J.P.	Very good.
			nearly full light	10	36	9·6			
„ 20	III	Tr. E.	bisection	11	2	54·6		„	Steady.
			external contact	11	7	20·6			
	„	Sh. I.	bisection	12	1	3·6		„	
			internal contact	12	5	26·1		W.C.	
„ 25	II	Tr. I.	external contact	5	56	54·8		W. McK.	Unsteady.
			bisection	5	59	41·8			
			internal contact	6	2	39·3			
	„	Sh. I.	bisection	8	24	22·4		W.C.	Good; cloudy, tremulous.
			internal contact	8	25	43·7			
	„	Tr. E.	internal contact	8	47	56·9		W. McK.	
			bisection	8	52	11·7			
			external contact	8	54	26·4			
	IV	Ec. D.	half light	9	23	57·8		S.J.P.	Sky very clear; compared with Satellite II.
			quarter light	9	26	11·6			
			last seen	9	29	38·8	−4 50·2		
	II	Sh. E.	bisection	11	11	39·5		W. McK.	Rather indistinct; approximate.
„ 27	„	Ec. R.	first seen	5	23	16·2	−0 32·8	S.J.P.	Compared with Satellite I.
			half light	5	25	8·2			
			full light	5	27	17·7			

1879.	Satellite.	Phenomenon.	G.M.T. h	m	s	In excess of *N.A.* m	s	Observer.	Remarks.
	III	Tr. I. external contact	11	3	21·5			W. McK.	External contact perhaps too early; poor definition; very unsteady.
		bisection	11	8	26·0				
		internal contact	11	14	19·5				
Nov. 1	II	Tr. I. external contact	8	29	15·6			S.J.P.	Rather tremulous.
		bisection	8	32	19·5				
		internal contact	8	34	46·7				
,, 2	IV	Tr. I. external contact	8	15	58·0			,,	External contact possibly a trifle late; definition good.
		bisection	8	19	21·0				
		internal contact	8	23	17·0				
,, 7	I	Oc. D. external contact	7	14	1·8			W.C.	Cloud; very poor.
		bisection	7	14	59·3				
,, 10	II	Oc. D. external contact	5	9	27·2			S.J.P.	Very steady; definition good. Between bisection and disappearance satellite apparently projected on to limb.
		bisection	5	12	37·5				
		last seen	5	15	36·2				
	,,	Ec. R. first seen	10	36	49·2	−0	26·8	,,	Slightly hazy.
		half light	10	39	37·5				
		full light	10	41	40·7				
,, 14	III	Oc. D. external contact	8	31	48·5			,,	
		bisection	8	35	26·0				

			last seen	8	39	59·0			
	I	Oc. D.	external contact	9	7	0·0		,,	
			bisection	9	10	13·0			
			last seen	9	12	41·0			
,, 23	,,	Oc. D.	external contact	5	28	14·8		W.C.	Very unsteady.
			bisection	5	30	50·3			
			last seen	5	33	0·3			
	,,	Ec. R.	first seen	9	11	31·1	+0 12·1	,,	Slightly hazy; good. Compared with Sat. II.
			half light	9	12	16·3			
			full light	9	13	4·1			
,, 27	IV	Oc. D.	external contact	8	51	41·4		S.J.P.	Clear, but unsteady, passing clouds; approx.
			bisection	9	0	23·9			
,, 30	I	Oc. D.	external contact	7	25	56·2		W.McK.	Unsteady.
			bisection	7	28	21·7			
			last seen	7	30	40·2			
Dec. 1	,,	Sh. I.	internal contact	6	2	34·5		W.C.	Good; shadow very dark.
	,,	Tr. E.	internal contact	6	54	28·0		,,	Satellite very faint.
			bisection	6	56	21·5			
			external contact	6	59	56·5			
	,,	Sh. E.	internal contact	8	14	3·7		,,	Very poor.
			bisection	8	15	50·2			
			last seen	8	17	34·2			

1879.	Satellite.	Phenomenon.	G.M.T. h	m	s	In excess of *N.A.* m	s	Observer.	Remarks.
Dec. 2	,,	Ec. R. first seen	5	36	13·8	+0	22·8	S.J.P.	Very good, sky not very clear; compared with Satellite III.
		full light	5	38	57·7				
	III	Tr. I. external contact	6	44	3·0			,,	Misty; definition very bad.
		bisection	6	51	25·5				
,, 3	III	Tr. I. external contact	8	5	34·9			,,	Definition very poor; hazy.
		bisection	8	9	3·1				
		internal contact	8	12	59·0				
,, 6	III	Ec. R. first seen	5	28	0·0			,,	
		half light	5	29	56·3				
		full light	5	32	8·6				
,, 8	I	Tr. I. bisection	6	36	4·1			W.McK.	
		internal contact	6	39	36·2				
	,,	Tr. E. bisection	8	57	58·8			S.J.P.	Misty, definition bad. After transit Satellite I. was only visible by glimpses, although the other satellites were well seen at the time. Cut off glare of planet, and yet Satellite I. only just visible for more than half an hour after transit. Used powers from 100 to 350.
		external contact	9	0	34·8				

Observations of Occultations of Stars by the Moon, and of Phenomena of Jupiter's Satellites, made at the Royal Observatory, Greenwich, in the Year 1879.

(*Communicated by the Astronomer Royal.*)

Occultations of Stars by the Moon.

Day of Obs. 1879.	Phenomenon.		Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
Mar. 30 (*a*)	Disapp. of Piazzi vi. 165		E. Eq.	310	Dark	7 16 3·8	AD
Apr. 30 (*b*)	,,	Bradley 1393	,,	140	,,	9 56 13·6	R
May 3	,,	*q* Virginis	Altaz.	100	,,	9 19 32·6	GP
July 28 (*c*)	,,	Antares	S.E. Eq.	220	,,	9 37 38·5	WC
,, (*d*)	,,	,,	Simms No. 2	60	,,	9 37 38·8	W
,, (*e*)	,,	,,	Altaz.	100	,,	9 37 38·9	BD
,, (*f*)	,,	,,	Simms No. 1	145	,,	9 37 39·2	M
,, (*g*)	,,	,,	E. Eq.	140	,,	9 37 39·2	GP
,, (*h*)	Reapp.	,,	Altaz.	100	Bright	10 6 44·6	BD
,,	,,	,,	E. Eq.	140	,,	10 6 46·0	GP
Aug. 25 (*i*)	Disapp.	Bradley 2174	,,	,,	Dark	8 5 38·9	AD
Sept. 26	,,	λ Capricorni	Altaz.	100	,,	10 40 20·1	T
Oct. 4	Reapp.	36 Tauri	E. Eq.	140	,,	11 39 35·8	TP
Nov. 18 (*k*)	Disapp.	σ Capricorni	,,	,,	,,	6 35 41·0	C
,, (*l*)	,,	,,	Altaz.	100	,,	6 35 42·4	AD
Nov. 22	,,	16 Piscium	E. Eq.	140	,,	7 55 43·7	C
Dec. 22 (*m*)	,,	101 Piscium	Altaz.	100	,,	5 6 55·4	T
,, (*n*)	,,	,,	E. Eq.	140	,,	5 6 57·4	C

Notes.

(*a*) Instantaneous; registered on the chronograph.

(*b*) Instantaneous.

(*c*) The *comes* disappeared gradually about 12 seconds before *Antares*. It was very distinctly seen just clear of the rays from *Antares*, and was of a deep blue colour. *Antares* disappeared instantaneously.

(*d*) The star's image blurred; disappearance instantaneous.

(*e*) The star seemed to disappear instantaneously, but was a little diffused about a second before disappearance.

(*f*) Instantaneous; observed with the Airy eye-piece. The companion was seen clearly till about two minutes before the disappearance, but the star then became very tremulous, and the companion was lost in its rays.

(*g*) Disappeared instantaneously.

(*h*) The limb of the Moon was rather tremulous, but the observed time is probably within half a second. No particular change of colour was noticed.

(*i*) Instantaneous; registered on the chronograph.

(*k*) Observation considered very good.

(*l*) Observation accurate; the observer could see the dark limb of the Moon; registered on the chronograph.

(*m*) Star faint; observation uncertain.

(*n*) Good.

Phenomena of Jupiter's Satellites.

Day of Obs.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation.	Mean Solar Time from *N.A.*	Observer.
1879.					h m s	h m s	
June 28	I	Tr. ing. first contact	Altaz.	100	13 3 13	13 12	AD
,,	I	,, last contact	,,	,,	13 8 57		
July 1	III	Ecl. reapp. first seen	,,	,,	13 6 46	13 8 35	C
Aug. 5	I	Ecl. disapp. first obs.	E. Eq.	140	13 6 16	13 8 20	AD
,,	I	,, last seen	,,	,,	13 8 50		
,, (*a*)	I	,, first obs.	S.E. Eq.	220	13 6 4	13 8 20	M
,,	I	,, dichotomised	,,	,,	13 7 14		
,,	I	,, last seen	,,	,,	13 9 1		
Aug. 6 (*b*)	II	Occ. reapp.	E. Eq.	140	12 49 38	12 51	J
Aug. 21 (*c*)	I	,, bisection	,,	,,	13 57 32	13 58	BD
,,	I	,, last contact	,,	,,	13 59 46		
Aug. 22	II	Tr. ing. last contact	Altaz.	100	9 4 53	9 4	R
,, (*d*)	II	Tr. egr. first contact	E. Eq.	140	11 52 26	11 55	,,
,,	II	,, bisection	,,	,,	11 54 6		
,,	II	,, last contact	,,	,,	11 55 36		
Aug. 28 (*e*)	I	Ecl. disapp. last seen	,,	,,	13 21 27	13 21 32	,,
Sept. 15	I	Ecl. reapp. first seen	,,	,,	8 24 29	8 24 25	AD
,,	I	,, full brightness	,,	,,	8 26 50		
Sept. 25	III	,, first seen	,,	,,	13 13 0	13 15 30	J
,,	III	,, half brightness	,,	,,	13 14 35		
,,	III	,, full ,,	,,	,,	13 16 50		
Oct. 7	I	Tr. Ing. first contact	,,	,,	8 9 20	8 11	
,,	I	,, bisection	,,	,,	8 12 19		
,,	I	,, last contact	,,	,,	8 15 29		

Day of Obs. 1879.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time from *N.A.* h m s	Observer.
Oct. 9	II	Ecl. reapp. first seen	E. Eq.	140	10 52 5	10 53 5	C
„ 15	I	„ „	„	„	10 35 17		
„	I	„ half brightness	„	„	10 36 36	10 35 8	J
„	I	„ full „	„	„	10 37 21		
Oct. 20 (*f*)	III	Tr. Ing. first contact	S.E. Eq.	130	7 30 51		
„	III	„ bisection	„	„	7 34 55	7 32	M
„	III	„ last contact	„	„	7 39 30		
Oct. 25	II	Tr. ing. first contact	E. Eq.	140	6 2 7	6 3	C
„	II	„ last contact	„	„	6 6 21		
„	II	Tr. egr. bisection	„	„	8 49 10	8 55	„
„	II	„ last contact	„	„	8 51 39		
„	IV	Ecl. disapp. last seen	„	„	9 29 53	9 34 29	„
Nov. 7	III	Occ. reapp. bisection	„	„	8 15 9	8 20	AD
„	III	„ last contact	„	„	8 17 24		
„ (*g*)	III	Ecl. disapp. first obs.	„	„	9 49 24	10 6 52	„
„	III	„ last seen	„	„	9 55 8		
Nov. 11 (*h*)	IV	Ecl. reapp. first seen	S.E. Eq.	310	7 37 23 ±	7 38 50	WC
„	IV	„ full brightness	„	„	7 53 20 ±		
„	IV	„ first seen	E. Eq.	140	7 37 1	7 38 50	AD
„	IV	„ full brightness	„	„	7 43 0		
Nov. 14	III	Occ. disapp. last contact	„	„	8 39 6	8 38	T
„	I	„ „	„	„	9 11 31	9 11	„
Nov. 15	III	Tr. ing. first contact	„	„	6 19 23		
„	III	„ bisection	„	„	6 21 3	6 19	AD
„	III	„ last contact	„	„	6 22 38		
Nov. 19 (*i*)	IV	Tr. egr. first contact	S.E. Eq.	220	6 5 1	6 20	M
„ (*k*)	IV	„ last contact	„	„	6 16 0		
Dec. 2 (*l*)	I	Ecl. reapp. first seen	E. Eq.	140	5 36 12	5 35 51	AD
„	I	„ full brightness	„	„	5 39 22		
„	III	Tr. ing. first contact	„	„	6 40 12	6 44	„
„	III	„ last contact	„	„	6 51 40		
„	I	Ecl. reapp. first seen	S.E. Eq.	130	5 35 48		
„	I	„ half brightness	„	„	5 36 54	5 35 51	M
„	I	„ full brightness	„	„	5 38 44		
„	III	Tr. ing. first contact	„	„	6 45 33		
„	III	„ bisection	„	„	6 49 3	6 44	„
„	III	„ last contact	„	„	6 52 47		

Day of Obs.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation.	Mean Solar Time from *N.A.*	Observer.
1879.					h m s	h m s	
Dec. 6 (*m*)	III	Ecl. reapp. first seen	„	285	5 27 20	5 30 42	„
„ (*n*)	III	„ „	T.C.	100	5 29 41	5 30 42	TP
Dec. 8 (*o*)	I	Tr. ing. first contact	E. Eq.	140	6 32 13		
„	I	„ bisection	„	„	6 35 28	6 35	J
„	I	„ last contact	„	„	6 38 48		

Notes.

(*a*) Definition very good; observed with the Airy eye-piece.

(*b*) Planet very tremulous; limb boiling.

(*c*) Tremulous.

(*d*) Definition good; the satellite was seen on *Jupiter* three or four minutes before the first contact.

(*e*) Disappeared close to the limb of *Jupiter*.

(*f*) Limb boiling.

(*g*) Observation not satisfactory; *Jupiter* was low down in the mist.

(*h*) Estimated time of reappearance; the satellite was first noticed one minute later, and was then quite faint.

(*i*) *Jupiter* very unsteady; limb boiling. The satellite was seen just for a moment, and was perhaps $\frac{1}{6}$ off the limb.

(*k*) Four minutes before, at $6^h\ 12^m$, the satellite was perhaps $\frac{3}{4}$ off. At $6^h\ 14^m$ it was suspected to be clear of the planet, but it seemed to join the limb again. Clouds were passing continually during the observation.

(*l*) Definition good at this and the following observation.

(*m*) The first faint sparkle of the satellite was admirably seen.

(*n*) Observed with the field half illuminated, while *Jupiter* was passing the wires in the Transit-Circle telescope.

(*o*) *Jupiter* very tremulous and ill-defined.

The clear aperture of the object-glass of the S.E. Equatoreal is $12\frac{3}{4}$ inches, of the East Equatoreal 6·7 inches, of the Altazimuth $3\frac{3}{4}$ inches, and of the Transit-Circle 8 inches.

The initials WC, C, AD, M, T, W, BD, R, GP, J, and TP are those of Mr. Christie, Mr. Criswick, Mr. Downing, Mr. Maunder, Mr. Thackeray, Mr. Wickham, Mr. Dennison, Mr. Robinson, Mr. Pearce, Mr. James, and Mr. Plucknett.

Royal Observatory, Greenwich,
1880, *January* 2.

On the Rotation-period of Jupiter.

By H. Pratt, Esq.

On the 24th July 1879, between $11^h\ 30^m$ and 12^h G.M.T., on turning my telescope on *Jupiter* for the first time this season, I saw, near the middle of the great white belt on the south of the equatoreal zone, a finely developed reddish spot, or short belt. At that time its apparent centre was about half-way from the central meridian to the preceding limb. From its definiteness of outline and vividness of colour, I concluded it would prove useful as a means of obtaining a new determination of the rotation-period; and accordingly made observations for this purpose on every available occasion, and from them have derived the results which are detailed below.

The only previous determinations of *Jupiter's* rotation-period with which I am acquainted, are as follows:—

Author.	Date.	Rotation-period. h	m	s	Authority.
Cassini	1665	9	55	49·5	Dick, *Celestial Scenery.*
,,	,,	9	56		Grant, *Hist. of Astron.*
,,	1672	9	55	50	,, ,,
,,	1692	9	50		,, ,,
Maraldi	1708	9	56	48	,, ,,
,,	1713	9	56		,, ,,
Sylvabelle	1773	9	56		Arago, *Pop. Astron.*
Herschel, W.	1779	9	55	40	Grant, *Hist. of Astron.*
,,	,,	9	55	48	,, ,,
Schroeter	1786	9	55	33·6	,, ,,
,,	,,	9	56	56	Arago, *Pop. Astron.*
,,	,,	9	55	18	,, ,,
Schmidt	No date	9	55	28·7	Chambers, *Astron.*
Mädler	1835	9	55	29·9	Hind, *Solar System.*
Airy	,,	9	55	21·3	*Mem. R.A.S.*, vol. ix.
Schmidt	1866	9	55	46·3	Webb, *Celes. Objects.*

Considering the three most recent determinations, when the observers, the instruments, and the methods were all of the best, it may seem folly even to attempt the work again. Indeed it may prove impossible ever to arrive at a nearer knowledge of the true rotation-period of the planet. Yet, as the harmony between those three results is not perfect, and in view of the suggested cause of discrepancy being a proper motion of the spots made use of, I beg to submit (with what value may be attached to them) the following observations and inferences therefrom.

L

The observations themselves consisted of the Greenwich Mean Times of the transits of the middle of the spot across *Jupiter's* central meridian. These were obtained by means of micrometer measures of the distances of the ends of the spot from the E. and W. limbs of the planet. When these distances were equal it was concluded that the middle of the spot was on the central meridian. My clock's rate had been kept corrected by the frequent use of my transit-instrument.

The times of transit of the spot, found in this manner, were :—

			h	m	s
1	1879	July 26	12	25	0
2	,,	Sept. 3	9	19	
3	,,	,, 10	10	1	30
4	,,	,, 27	8	59	
5	,,	Oct. 1	12	15	30
6	,,	,, 6	11	22	15
7	,,	,, 26	7	50	
8	,,	Nov. 2	8	35	20
9	,,	,, 5	6	4	20
10	,,	,, 12	6	50	
11	,,	,, 19	7	35	30
12	,,	Dec. 6	6	36	

Arranging these observations in two series; taking them consecutively in pairs; and designating the intervals in the first series, between 1 and 2 (a), 2 and 3 (b), 3 and 4 (c); and in the second series between 1 and 2 (α), 1 and 3 (β), 1 and 4 (γ), and so on, we have :—

Intervals.	No. of Rotations.	Time elapsed in Mean Solar Seconds.
(a)	94	3,358,440
(b)	17	607,350
(c)	41	1,465,050
(d)	10	357,390
(e)	12	428,805
(f)	48	1,715,265
(g)	17	607,520
(h)	7	250,140
(i)	17	607,540
(j)	17	607,530
(k)	41	1,465,230
(α)	94	3,358,440
(β)	111	3,965,790
(γ)	152	5,430,840

Intervals.	No. of Rotations.	Time elapsed in Mean Solar Seconds.
(δ)	162	5,788,230
(ϵ)	174	6,217,035
(ζ)	222	7,932,300
(η)	239	8,539,820
(θ)	246	8,789,960
(ι)	263	9,397,500
(κ)	280	10,005,030
(λ)	321	11,470,260

The method by which I have arrived at the final result has been to take, as an assumed period of rotation, 35,726 seconds, multiply it by the number of rotations, and, after having corrected it for the difference of the Jovi-centric longitudes of the Earth at the two stations, to subtract the total from the time elapsed. Then, if the assumed rotation-period is in accord with the observed times when the middle of the spot was found to be on the planet's central meridian (allowing for the equation of light), there will be no remainder. If it is not so, then the remainder divided by the number of rotations will give a result which, after it is corrected for the differences of the equation of light due to the varying distances between the Earth and *Jupiter* at the times of the two observations under discussion, will give the final correction to the assumed rotation-period which the case requires.

As this last correction is in every case *plus*, it remains merely to add it to the assumed period in order to obtain that value of the time of *Jupiter's* rotation which is indicated by that pair of observations.

Treating the whole of the two series, in pairs of observations, by this method, I obtain the following corrections :—

	secs.		secs.
(a)	7·06	(α)	7·06
(b)	4·86	(β)	6·71
(c)	9·73	(γ)	7·47
(d)	15·23	(δ)	7·99
(e)	8·13	(ϵ)	7·96
(f)	7·86	(ζ)	7·90
(g)	7·57	(η)	7·97
(h)	6·95	(θ)	7·92
(i)	7·70	(ι)	7·78
(j)	7·68	(κ)	7·72
(k)	7·60	(λ)	7·43
Mean	8·21	Mean	7·62

and

$$\frac{8\cdot21 + 7\cdot62}{2} = 7\cdot91 \text{ secs.} = \text{the final correction.}$$

With regard to the relative value of the two series, undoubtedly that of the second is the greatest, for including as it does a much larger number of rotations of the planet between each pair of observations, its results must therefore be the more accurate of the two.

From the fairly close accord between the means of the two sets of double observations, we may assume with great probability *that the spot was without variable proper motion*; for what differences there are arise more probably from the unavoidable errors of observation. But I have thought it best to exhibit them thus plainly in order that a proper estimate may be formed of the whole matter; for, after all, the difference of the means does not exceed one second of time.

Therefore, if the mean of those two means, $= 7^{s}\cdot91$, is added to the assumed period, giving $9^{h}\ 55^{m}\ 33^{s}\cdot91$ of Mean Solar Time, that may perhaps be accepted as the nearest approximation which I am able to derive from the whole of my observations, which include 321 rotations of *Jupiter*.

By substituting for the assumed period this now corrected value of it, and by calculating what should have been, according to it, the times of transit of the spot across *Jupiter's* central meridian on the dates of observation, we arrive at the following discrepancies between prediction and observation:—

	In Time. secs.		In Jovi-centric longitude. °
(α)	+ 79	or	0·7
(β)	+132	,,	1·3
(γ)	+ 65	,,	0·6
(δ)	− 14	,,	0·01
(ε)	− 20	,,	0·2
(ζ)	− 9	,,	0·09
(η)	− 15	,,	0·01
(θ)	− 5	,,	0·05
(ι)	+ 33	,,	0·3
(κ)	+ 54	,,	0·5
(λ)	+154	,,	1·5

from which it is apparent that the greatest of these discrepancies is 154^{s} in time of observation, equal to $1°\cdot5$ of longitude on *Jupiter*, which is well within the limits of possibility.

From the experience gained in making the original observations, I have concluded that it would have been impossible for me to have made an error exceeding two minutes, or two minutes and a half, in determining the times of central transit across *Jupiter's* disk. This amount doubled, as a possible excess and defect at the times of the first and last observations, amounts to

but $\frac{1}{38,000}$th of the whole. From which it follows that *the probable error* in my determination is less than one second of time.

The rotation-period which is perhaps most frequently quoted in astronomical books is $9^h\ 55^m\ 26^s$. During the 321 rotations which I have observed during this series, that period would produce a discordance equal to $42^m\ 19^s$; and by that time, not only the middle, but the following end of the spot would have considerably passed the central meridian on the date of the last observation. It is therefore plainly evident that the most generally quoted value of the rotation-period is completely out of harmony with the present series of observations.

I gladly acknowledge the assistance derived from the perusal of the valuable paper, "On the Determination of the Rotation-period of *Jupiter* in 1835," to be found in vol. ix. of the *Memoirs*, by the Astronomer Royal, whose method to some extent I have followed.

18 *Preston Street, Brighton,*
1880, *January* 8.

Estimated Times of Transit of the Red Mark on Jupiter across the Central Meridian. By T. W. Backhouse, Esq.

1879.		G.M.T.			Long.			
Mo.	Day.	Pr. End. h m	Middle. h m	Foll. End. h m	Pr. End. °	Middle. °	Foll. End. °	Length. °
8	29		10 14			255		
9	22	9 29	9 33	10 23	245	261	278	33
	29		10 43			264		
10	6	10 59*	11 23		248	263		
	28			9 56			283	
11	7			8 17†			288	
	10			5 44			287	
	17	5 35‡			260			
	29		5 53§	6 21§		271	287	
12	6	6 14§	6 40§	7 10§	256	272	290	34
	13		7 35‡			278		
	23	5 18§	5 48§	6 15§	259	277	293	34
	25	7 1	7 27	7 56‡	262	278	295	33

* Main part. A slender point extends a little further pr.
† Thickish cloud.
‡ Definition bad.
§ Definition not good.

Estimations made with a $4\frac{1}{4}$-in. Refractor.

Sunderland,

Means of Daily Areas of Umbræ, Whole Spots, and Faculæ upon the Sun's Disk, as measured on Photographs taken at the Royal Observatory, Greenwich, for each Rotation of the Sun, from 1877, December 22, to 1879, December 28.

[In continuation of the results printed in the *Monthly Notices*, vol. xxxix., p. 515.]

(*Communicated by the Astronomer Royal.*)

The Mean Daily Areas have been formed by taking the Means of the Areas for each day of observation throughout each rotation of the Sun, and are expressed in millionths of the Sun's visible hemisphere. Usually two photographs are taken on each day of observation.

No. of Rotation.	Date of Commencement of each Rotation.	No. of Days of Obs.	Means of Daily Areas.		
			Umbræ.	Whole Spots.	Faculæ.
65	1877 Dec. 22	7	0	5	128
66	1878 Jan. 16	8	8	66	81
67	Feb. 10	8	5	25	129
68	Mar. 8	6	11	50	0
69	Apr. 2	9	0	0	0
70	Apr. 28	10	0	0	11
71	May 23	8	16	75	347
72	June 17	17	6	35	105
73	July 13	16	0	1	64
74	Aug. 7	13	0	0	8
75	Sept. 1	16	19	90	180
76	Sept. 27	14	0	0	90
77	Oct. 22	10	6	23	35
78	Nov. 17	4	0	0	85
79	Dec. 12	2	0	0	0
80	1879 Jan. 6	2	0	0	0
81	Feb. 1	7	0	0	29
82	Feb. 26	10	0	0	0
83	Mar. 23	9	11	56	124
84	Apr. 18	11	4	17	51
85	May 13	10	0	0	63
86	June 8	12	12	47	60
87	July 3	7	2	15	370
88	July 28	12	11	29	80
89	Aug. 23	11	16	76	66
90	Sept. 17	12	14	45	268
91	Oct. 12	9	45	206	336
92	Nov. 7	9	25	108	211
93	Dec. 2	6	4	17	618

Means of Daily Areas of Umbræ, Whole Spots, and Faculæ upon the Sun's Disk, as measured on Photographs taken at the Royal Observatory, Greenwich, for each Year, from 1873 *to* 1879.

The Mean Areas are expressed in millionths of the Sun's visible hemisphere.

Year.	Means of Daily Areas.		
	Umbræ.	Whole Spots.	Faculæ.
1873	116	678	2882
1874	83	583	1095
1875	45	255	475
1876	25	132	226
1877	20	94	168
1878	5	25	84
1879	10	44	163

Many of the photographs taken during the early part of 1874 do not show the faculæ with sufficient distinctness to allow of their measurement; the mean area of faculæ given for that year is therefore too small.

The mean daily area of faculæ for the half-year beginning 1874, July 2, is 1257.

From these results it appears that the minimum both for Sun-spots and faculæ occurred about the end of 1878 and the beginning of 1879, and that there has since been a marked increase in the number of both.

Royal Observatory, Greenwich,
1880, *Jan.* 9.

Note referring to Observations and Estimations of the Brightness of Mars, which ought to be made in February and March 1880.

By A. Marth, Esq.

The apparent brightness of the planet *Mars* is now decreasing at such a rate, that in the course of February it will be reduced to that of some of the fixed stars of the first magnitude. The planet is unusually well placed for comparison with *α Tauri* and *α Orionis*, both stars of reddish hue and consequently better adapted for the purpose than others of different colour, and observers who may be favoured by clear evenings in the latter part of February and beginning of March ought therefore not to lose their opportunities for making such photometric measurements or naked-eye estimations as will serve to fix the time when *Mars* equals in brightness *α Orionis* and the time when it equals *α Tauri*. Seventy-nine years ago, on a certain evening in February 1801, Olbers estimated that *Mars* appeared just as

much brighter than α *Tauri* as it appeared fainter than α *Orionis*, and he made this estimate the foundation of his paper, "*Mars und Aldebaran*," in vol. 8 of Zach's *Monatliche Correspondenz*. The circumstances of the present apparition of the planet are not much different from those in 1801, and Olbers' old estimate accordingly suggests the time when *Mars* is likely to appear of the corresponding brightness. But since α *Orionis* is a variable or at least a suspected variable star, proper allowance must be made, and the comparisons must begin sufficiently early in February. The moonlight may be troublesome for some evenings, but this cannot be helped.

The ratio of the apparent brightness of *Mars* to that at mean opposition can only be given conditionally, since the real effect of the phase is not yet ascertained. If r is the distance of the planet from the Sun, Δ its distance from the Earth, and (in the notation of Lambert's photometric formula) v the phase-angle, or $180° - v$ the areocentric angle between Sun and Earth, the light-ratio will be

$= \frac{\text{const.}}{r^2 \cdot \Delta^2} \cdot \sin^2 \frac{1}{2}v$, in case the amount of light depends simply on the proportion of the illuminated portion to the whole disk;

or

$= \frac{\text{const.}}{r^2 \cdot \Delta^2} \cdot \frac{\sin v - v \cos v}{\pi}$, in case Lambert's photometric formula is valid.

In order to refer the brightness to that at mean opposition, the const. c is put $= a^2(a-1)^2$, where a is the major semi-axis of the planet's orbit, or $\log c = 9{\cdot}803945$.

The following table gives, for Greenwich Noon, the values of $\log \frac{c}{r^2 \cdot \Delta^2}$, of the phase-angle v, and of the logarithms of the light-ratios in the two cases :—

1880.	$\log \frac{c}{r^2 \cdot \Delta^2}$.	v.	$\log \left(\frac{c}{r^2 \cdot \Delta^2} \cdot \sin^2 \frac{1}{2}v \right)$.	$\log \left(\frac{c}{r^2 \cdot \Delta^2} \cdot \frac{\sin v - v \cos v}{\pi} \right)$.
		°		
Feb. 18	9·22960	141·84	9·1805	9·1414
20	·21421	141·85	·1651	·1261
22	·19905	141·87	·1500	·1110
24	·18414	141·91	·1352	·0963
26	·16945	141·96	·1207	·0818
28	·15500	142·02	·1064	·0676
Mar. 1	·14077	142·09	·0923	·0537
3	·12676	142·18	·0735	·0400
5	9·11296	142·27	9·0650	9·0267

Since *Mars* is near quadrature, and the angle v varies little, the uncertainty of the photometric formula will not sensibly affect the relative comparisons made during the interval.

The correction of the observations which takes into account the extinction of light in different zenith-distances may be diminished or avoided in case it is feasible to observe at the times when both objects are at the same zenith-distance. *Mars* and *α Orionis* allow this to be done till the beginning of March. If the angle τ is found from $\sin \tau = \nu \tan$. latitude, and expressed in time, the two bodies will be at the same altitude at the local sidereal time $\theta_o + \tau$. The values of $\log \nu$ and θ_o are given for 8^h G.M.T. in the following table, together with the times of the occurrence at Greenwich :—

Mars and *α Orionis*.

8^h Gr.	$\log \nu$.	θ_o.	At Greenwich.		
		h m	h m	h m	°
Feb. 18	9·7387	4 20·8	7 15 Sid.T.	= 9 24 M.T.	47·5 Z.D.
22	9·7810	4 20·9	7 34	9 26	49·2
26	9·8259	4 20·5	8 5	9 41	52·5
Mar. 1	9·8744	4 19·2	9 0	10 19	59·0
5	9·9264	4 16·7	...	...	...

Mars and *α Tauri* will not be observable in this way in our latitudes. But *α Tauri* and *α Orionis* will be at the same zenith-distance, if τ is found by $\sin \tau = [9{\cdot}6506]$ tan.latit., at $4^h\ 47^m{\cdot}6 + \tau$ local sidereal time, or for the latitude of London, at $7^h\ 4^m$ sidereal time, the zenith-distance being 46°·8.

Observation of the Outer Satellite of Mars, made at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The following micrometer measures of *Deimos* were obtained with the great Equatoreal ($12\frac{3}{4}$ inches aperture) on the evening of 1879, November 12. It was also seen for a few moments on November 7, but no measures could be obtained on that occasion. The inner satellite, *Phobos*, was never seen.

1879, Nov. 12.

Measures of Distance.

Greenwich Mean Solar Time.			Greenwich Sidereal Time.			Distance in Arc.
h	m	s	h	m	s	″
11	24	21	2	51	12	66·47
11	49	27	3	16	22	62·77
12	23	3	3	50	4	60·46
12	44	45	4	11	49	58·14

Measures of Position.

Greenwich Mean Solar Time. h m s	Greenwich Sidereal Time. h m s	Position-angle. ° ′
11 17 4	2 43 54	229 34
11 44 45	3 11 39	228 8
12 15 30	3 42 29	226 21
12 39 36	4 6 39	226 27*

The satellite, once found, was an easy object at greatest elongation. It became very difficult before the last observations, as the definition was then much impaired. It bore a fair amount of illumination in the field, but the measures were taken in a dark field, the wires only being bright. The determination of the position-angle was much more difficult and less certain than that of the distance. *Mars* was observed through a dark glass, which was placed in front of the eye-piece and covered half the field. Power employed, 295.

Observer, Mr. Maunder.

Royal Observatory, Greenwich,
1880, *Jan.* 9.

The Greenwich Standard Right Ascensions.

By A. M. W. Downing, Esq.

The Greenwich Standard Right Ascensions now in use are based on a determination of the right ascensions of clock-stars in which only those observations were included where the group of clock-stars extended over 12 hours at least. These results would presumably be independent of the assumed places of the clock-stars, and may be considered as the best standard places of fundamental stars which can be obtained from the Greenwich observations in the years 1868 to 1876.

These right ascensions are given in the Introduction to the Greenwich Nine-Year Catalogue.

I have thought that it would be interesting and instructive to compare these Greenwich places with the right ascensions of the fundamental stars as given by some of the most eminent authorities, in order to show the differences that exist, not only in the adopted equinoxes of the several Catalogues, but also in the places of individual stars. For this purpose I have selected for comparison the Standard Catalogues published by Newcomb, by Gyldén, and by Auwers. Newcomb's Catalogue is given in the volume of *Washington Observations* for 1870, Gyldén's in the *Monthly Notices* for 1875, May, and Auwers' in the *Publication der Astronomischen Gesellschaft*, No. xiv.

* Rough bisection; satellite becoming very difficult to observe.

The comparison with Newcomb shows plainly enough, from the constancy of the differences all through, that the places in the two Catalogues are not affected by any appreciable error of a periodic character depending either on the right ascension or on the declination. The resulting mean correction to Newcomb is $-^{s}\cdot029$; this, therefore, is the difference between the adopted eqinoxes of the Catalogues. If this correction be applied, the individual results are found to agree very closely; the only cases of a correction exceeding $^{s}\cdot02$ being α *Canis Minoris* $+^{s}\cdot023$ (on account of its orbital motion, this star should perhaps be rejected altogether), α^2 *Libræ* $+^{s}\cdot027$, and α *Lyræ* $-^{s}\cdot024$. In *Monthly Notices*, 1875, Suppl. Number, Professor Newcomb points out that the mean correction to his right ascensions from the Greenwich observations of the Sun, 1836–1870, is $-^{s}\cdot028$, so that very little change seems to have taken place in the position of the Equinox as found from the more recent observations.

In the comparisons with Gyldén and Auwers, I have only used the stars that are given by Newcomb, as these are sufficiently numerous to determine the difference between the adopted equinoxes, and the Greenwich places may safely be assumed to be sensibly free from periodic error; so that the places of many stars are unnecessary, it being no part of my present object to determine the periodic errors (if any such exist) of the other Catalogues. Gyldén's right ascensions agree closely with Greenwich, the differences are nearly constant through the 24 hours, and the mean correction is $-^{s}\cdot016$; when this is applied the only individual stars that stand out are β *Orionis* $-^{s}\cdot024$, α^2 *Libræ* $+^{s}\cdot030$, and β *Aquilæ* $+^{s}\cdot026$. Auwers' *Catalog der Fundamental-Sterne* gives for mean correction $-^{s}\cdot026$, and we then have for α *Arietis* the correction $-^{s}\cdot021$, for α *Leonis* $+^{s}\cdot025$, and for α *Lyræ* $-^{s}\cdot028$.

It appears then that the most important difference between the Greenwich right ascensions and the places furnished by these distinguished astronomers, with which they are compared, is a difference in the adopted equinoxes, and this is really the puzzling circumstance in all determinations of right ascension. By the exercise of a due amount of care in the methods of observation and of reduction it is possible, practically, to get rid of the errors affecting the relative right ascensions of stars; but it has hitherto been found impossible wholly to eliminate the errors which affect the absolute right ascensions. As an illustration of the difficulty in this matter, I may refer to the table on page 3 of the Introduction to the Greenwich Nine-Year Catalogue, from which it appears that the corrections to the assumed equinox from observations of the Sun ranged from $+^{s}\cdot058$ in 1873 to $-^{s}\cdot049$ in 1874, and the mean error of the resulting correction from the nine-years' observations is as much as $\pm^{s}\cdot012$. The following results, extracted from Nyrén's *Das Æquinoctium für* 1865·0, in which that astronomer determines the equinox from the Pulkowa Observations of the Sun, 1861–1870, with his usual care and completeness, will also illustrate the difficulty of making a satisfactory determination.

Pulkowa (1865)	– Greenwich (1836–70)	= +0·064
	– Pulkowa (1845)	= +0·055
	– Edinburgh	= +0·036
	– Cambridge	= +0·030
	– Paris	= +0·011
	– Washington	= −0·002

This remarkable difference between Greenwich and Washington is also pointed out by Newcomb in the paper referred to above.

We must, I suppose, consider these discordances to arise from casual errors of observation. It is, however, much to be wished that more Observatories would co-operate in the work of continuous meridian observation of the Sun and principal stars, and especially valuable would be the results of observations made at stations where the Sun culminates at a considerable altitude when near the Equator.

Corrections to three selected Catalogues, derived from a Comparison with the Greenwich Standard Right Ascensions of Clock-Stars, based on 12*-hour Groups.*

Name of Star.	Newcomb (1872). I. s	Newcomb (1872). II. s	Gyldén (1875). I. s	Gyldén (1875). II. s	Auwers (1875). I. s	Auwers (1875). II. s
α Andromedæ	−·034	−·005	−·007	+·009	−·034	−·008
γ Pegasi	·032	·003	·001	·015	·028	·002
α Arietis	·045	·016	·019	−·003	·047	·021
α Ceti	·047	·018	·034	·018	·035	·009
α Tauri	·026	+·003	·023	·007	·012	+·014
β Orionis	·020	·009	·040	·024	·016	·010
β Tauri	·026	·003	·022	·006	·018	·008
α Orionis	·027	·002	·036	·020	·018	·008
α Canis Min.	·006	·023			·006	·020
β Geminorum	·033	−·004	·034	·018	·033	−·007
α Hydræ	·018	+·011	·019	·003	·027	·001
α Leonis	·026	·003	·020	·004	·001	+·025
β Leonis	·012	·017	·009	+·007	·010	·016
α Virginis	·028	·001	·025	−·009		
α Boötis	·038	−·009	·012	+·004	·035	−·009
α^2 Libræ	·002	+·027	+·014	·030		
α Coronæ	·045	−·016	−·017	−·001	·036	·010
α Serpentis	·035	·006	·022	·006	·026	·000
α Scorpii	·027	+·002	·018	·002		
α^1 Herculis	·035	−·006	·020	·004	·034	−·008

Name of Star.	Newcomb (1872). I. s	Newcomb (1872). II. s	Gyldén (1875). I. s	Gyldén (1875). II. s	Auwers (1875). I. s	Auwers (1875). II. s
α Ophiuchi	·036	·007	·026	·010	·042	·016
α Lyræ	·053	·024	·011	+·005	·054	·028
γ Aquilæ	·038	·009	·010	·006	·027	·001
α Aquilæ	·036	·007	·018	−·002	·027	·001
β Aquilæ	·025	+·004	+·010	+·026	·013	+·013
α^2 Capricorni	·018	·011	−·005	·011		
α Aquarrii	·026	·003	·006	·010	·028	−·002
α Piscis Aust.	·027	·002				
α Pegasi	−·023	+·006	−·001	+·015	−·015	+·011

The numbers under the columns headed I are the actual differences between the Catalogue places, those under the columns headed II are the differences when a constant correction of $-^{s}\cdot029$ is applied to Newcomb, $-^{s}\cdot016$ to Gyldén, and $-^{s}\cdot026$ to Auwers.

1879, *Jan.* 8.

On the Effects of "Personality" on the Tabular Errors of the Moon. By E. Dunkin, F.R.S.

In Mr. Neison's interesting Paper on the effects of personality on the Greenwich tabular errors of the Moon (*Monthly Notices*, vol. xl. pp. 75–80) there are one or two points having reference to some expressions and deductions of mine contained in a Paper inserted in vol. xxix. of the *Monthly Notices*, on which I think I ought to make a few remarks, principally, however, in the way of explanation. The subject has for many years been one of considerable interest to me, since, in fact, the year 1848, when the remarkable personal equation in observing the limbs of the Moon between Mr. H. Breen and myself was first noticed.

The first point to which I wish to call attention is the paragraph in Mr. Neison's Paper in which he states that "it appeared that Mr. Dunkin had based his investigation on the assumption that 'the mean tabular errors are assumed to be constant throughout the mean lunation.' It is now known that this assumption is not a permissible one, for the tabular errors are not constant throughout the mean lunation, but that, owing to imperfections in the theory, they are systematically different before and after full Moon." Through a fault of my own in the construction of the sentence, Mr. Neison has been led unfortunately to misunderstand my meaning in the above quotation, for the information I intended to convey to the reader was, "provided the (relative) mean tabular errors are assumed to be constant

throughout the mean lunation." This remark, I contend, is sufficiently accurate for the purpose I had in view, knowing that the four observers had an equal and regular share in the observations. I was not concerned in determining the varying absolute amounts of tabular errors in the course of the year; all that I assumed was that, in the mean yearly groups of the different observers, the relative tabular error might be considered to be constant; and I had specially mentioned that, to ascertain whether the mean relative tabular errors represented the same point in the Moon's orbit, I had arranged all the errors for each observer according to the age of the Moon, when it was found that the mean age agreed sensibly for all, for observations both of the first and second limbs. It appears to me that the general accordance of the results exhibited in the tables given in my former Paper is a sufficient proof that they can only be slightly affected by any relative difference of tabular error; and probably, if I had to go over the work again, I should make no material modification which could sensibly influence the results.

I do not clearly understand the process by which Mr. Neison obtains the numbers inserted in the table on page 79. It appears to me that we are not at all certain that personal equations are so constant as to assume that no change has taken place in that of any person between 1863 and 1876; indeed there is some evidence that changes have actually occurred in personal equations when derived from the observations of the transits of stars. For this reason, I rather doubt the advisability of comparing, by an indirect method, the observations made by me in 1863–69 with those made by Mr. Thackeray in 1875–76, especially as the observations of the latter were far too few in these years to give a reliable determination. As an example of a progressive change of personal equation, I have only to refer to the case of Mr. Rogerson, in whom it varied in the eight years from 1846 to 1853 from $0^s.31$ to $0^s.67$, by a nearly equal increment each year. We ought therefore to be quite certain of our data before coming to a conclusion, especially in regard to such small quantities as we are obliged to deal with in investigations of this nature.

Now I must ask the question whether Mr. Neison has had reliable data before him with regard to the more recent observers, sufficient to prove that "the change of observers has therefore introduced a considerable increase in the mean tabular error of the Moon which has no real existence." (P. 79.) I think not. I have been led to this opinion from an examination of the tabular errors of longitude of the Moon determined in 1877 and 1878 when we have had a fair number of observations made with the Transit-Circle by Mr. Downing and Mr. Thackeray to deal with. I have grouped together the errors under the names of Mr. Lynn (who observed only in 1877 and in the early months of 1878), Mr. Criswick, Mr. Downing, and Mr. Thackeray; the means were then taken and referred to Mr.

Criswick's mean as the standard. The following is the result:—

	1877.	1878.	Mean 1877–78.
	"	"	
Lynn —Criswick =	+0·54	...	+0·54
Downing — „ =	−1·02	−0·27	−0·72
Thackeray— „ =	−1·02	+0·95	−0·10

These numbers seem to show that we must look to some other cause than that assigned by Mr. Neison to explain any increase in the mean tabular error of the Moon. The figures point towards a decrease in the error rather than an increase; but they also prove that it is unsafe to base any particular theory on results liable to such fluctuations as those exhibited in this table.

Kidbrooke, Blackheath,
1880, *January* 8.

Note on the Remeasurement of a Lunar Photograph, in reply to Mr. Neison's Criticism. By Prof. C. Pritchard.

In the *Monthly Notices* of November last, Mr. Neison did me the honour of criticising a paper of mine laid before the Astronomical Society in June of the same year. In that paper I presented to the Society what seemed to me to be a question of considerable novelty and interest, viz. the measurement of the Moon's mean semi-diameter from a series of photographs taken by Mr. Jenkins with Mr. De La Rue's Reflector, the admirable defining power of which is generally acknowledged. I explained that the computation of the Moon's diameter was not the ultimate object for which the photographs were originally taken, but that, if I found a considerable number of them, taken at random out of many hundreds, gave accordant results, this circumstance would give me confidence in applying the fine series of photographs in the possession of the University of Oxford to the determination of the lunar physical libration; the latter investigation, it may be observed, involving an enormous expenditure of labour, and not to be undertaken without adequate grounds of confidence. The results of the computation of this diameter exhibited an amount of accordance which not only satisfied, but surprised me, when I reflected on the discordances arising from other known methods of observing. These results of very laborious measurement and computation I laid before the Society, and I thought them creditable both to the photography and to the computation.

Mr. Neison, however, in his criticism thinks it right to say: "Until we know the method by which these measures have been reduced, it is impossible to say how far the above result indicates

the true photographic semi-diameter, or how far it may be vitiated by the effect of the inequalities on the limb. In the method employed by Wichmann, the effect of these inequalities is not eliminated; and if Professor Pritchard has employed the same method, they will not have been eliminated from the above result."

The method of measurement was stated by me in the second and third paragraphs of my communication of June last. Substantially it is Bessel's with some modifications suggested by the peculiarity of Mr. De La Rue's measuring engine. As to the mode of reduction of these measurements, this also is substantially Bessel's; and in fact is the only natural one that would suggest itself to any mathematical astronomer.

However, I hope before a few months are over, to lay the matter in all its details before astronomers, so soon as the second fasiculus of the work done in the last two years at the University Observatory of Oxford can be published. Still, as Mr. Neison's criticism seemed to me to have a tendency to throw some doubt over the substantial accuracy of the method having in view the inequalities of the lunar contour, I arranged for the remeasurement of the semi-diameter of some one photograph taken entirely at random, and that by both the Observatory Assistants, superadded to a measure of my own.

The photograph selected was taken on January 26, 1877, just three years ago. Mr. Plummer selected, at his own judgment, eight points on the limb, measuring their distances from the centre of *Hypatia* B. Mr. Jenkins selected seven other points on the same limb, and measured from the same spot. Measures taken by myself, Mr. Plummer, and Mr. Jenkins of the same distances were compared together and the means of our measures did not differ by more than $0''{\cdot}15$ in about $600''$. Consequently no appreciable "personality" existed in the results of our mode of measuring these lunar distances. Neither can I see how such "personality" could exist in a microscope measure, when due care is taken to destroy parallax and to ensure all proper and obvious instrumental adjustments. The measures were then subjected to computations, the same as would be adopted by any competent astronomer.

Now let it be admitted that there are irregularities in the lunar contour, as assuredly there are; nevertheless here are measures, taken from a well-defined point on the lunar photograph to 23 points on the limb, in parts of it of more than average evenness; and what is the result? The original photographic mean semi-diameter was, as is stated (page 449, line 14) $15'\ 34''{\cdot}26$. The new measures of January 1880 give

	′	″
For Mr. Plummer	15	34·58
„ Mr. Jenkins	15	34·02
The mean is	15	34·30

THE PLEIADES

including the

NEBULA ROUND MEROPE.

(To be viewed at a distance of 6 feet.)

HALL
JAMAICA.
1877 March 6.

Spottiswoode & Co. Lith. London.

which shows, I think, conclusively how very little the first result is affected by the introduction of 15 fresh measures. Further still, I would appeal to astronomers who are experienced in delicate and accurate micrometrical measurement whether a greater degree of accordance could be expected even if the Moon's contour were absolutely uninterrupted. I trust Mr. Neison may not think it desirable here to repeat his former criticism of "fortuitous coincidence." I claim for them the natural results of some instrumental experience and some astronomical skill.

Oxford, Jan. 9, 1880.

The Lithograph of the *Pleiades*, including the Nebula round *Merope*, belongs to Mr. M. Hall's paper, "The Nebula in the *Pleiades*," printed in the December No., pp. 89–90.

Changes of Relative Brightness of Jupiter's Satellites.

By C. E. Burton, Esq.

Perhaps I may be permitted to call the attention of those Fellows of the Royal Astronomical Society who are interested in the changes referred to in the above title to an essay by Dr. Rudolph Engelmann, of Leipzig, *Ueber die Helligkeitsverhältnisse der Jupiter's Trabanten*, Leipzig, 1871, which treats very fully of the connection between the brightness of the satellites and their places in their orbits, establishing the reality of such a connection in the case of IV., even going so far as to identify the period of axial with that of orbital revolution with certainty for this satellite, and rendering it probable that the first satellite also behaves similarly.

Perhaps I shall be pardoned for calling attention to the concluding paragraph of a Note on IV. published by me in the *Monthly Notices*, vol. xxxiii. pp. 472–4, years before I heard of Engelmann's results or labours, and taking a somewhat different line of argument from his, which leads, nevertheless, to the same result.

Observations of Eclipses, Occultations, and Phenomena of Jupiter's Satellites, made with the 8-inch Equatoreal (Cooke) at the Adelaide Observatory, South Australia. By C. Todd, Esq., Director of the Observatory.

Longitude, $9^h\ 14^m\ 21^s{\cdot}3$ E. | Latitude, $34^\circ\ 55'\ 33''{\cdot}8$ S.

1878.

Ref. No.	Date 1878.	Observer	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding Greenwich Mean Time. h m s	Time by *Nautical Almanac.* h m s	Apparent Error of *Nautical Almanac.* m s	Power.
1	July 5	T	IV. Sh. E.	About bisected	10 0 32·31	0 46 11·01	0 48	...	200
2	,,	,,	IV. Tr. I.	External contact	10 5 7·30	0 50 46·00	...	...	,,
3	,,	,,	IV. Sh. E.	Disappeared	10 5 22·30	0 51 1·00	...	...	,,
4	,,	,,	IV. Tr. I.	Bisected	10 12 24·29	0 58 2·99	0 46	...	,,
5	,,	,,	,,	Internal contact	10 16 49·28	1 2 27·98	...	...	,,
6	July 7	T	I. Oc. R.	First seen	8 36 17·77	23 21 56·47			
7	,,	,,	,,	About bisected	8 36 37·77	23 22 16·47	23 24	...	,,
8	,,	,,	,,	External contact	8 39 7·77	23 24 46·47			
9	July 21	T	I. Ec. D.	Disappearance	9 43 31·36	0 29 10·06	0 28 45	−0 25·06	,,
10	July 22	T	I. Sh. E.	Internal contact	9 5 0·06	23 50 38·76			
11	,,	,,	,,	About bisected	9 8 53·55	23 54 32·25	23 57	...	,,
12	,,	,,	,	Limb complete	9 9 49·55	23 55 28·25			
13	July 22	T	I. Tr. E.	Internal contact	9 10 36·55	23 56 15·25			
14	,,	,,	,,	Bisection	9 12 37·05	23 58 15·75	0 2	...	,,
15	,,	,,	,,	External contact	9 15 38·05	0 1 16·75			

16	July 22	T	II.	Ec. D.	Last seen	10 31 18·95	1 16 57·65	1 17 3	+0 5·35		„
17	July 23	T	I.	Oc. R.	External contact	6 38 12·50	21 23 51·20	21 18	...		„
18	July 26	T	III.	Tr. I.	External contact	8 14 0·35	22 59 39·05				
19	„	„		„	Bisected	8 19 13·35	23 4 52·05	23 3	...		„
20	„	„		„	Internal contact	8 23 58·35	23 9 37·05				
21	July 26	T	III.	Sh. I.	First seen	8 28 38·25	23 14 16·95				
22	„	„		„	Bisected	8 29 38·25	23 15 16·95	23 11	...		„
23	„	„		„	Internal contact	8 32 28·25	23 18 6·95				

Remarks.

Ref. No.

1 Late; clouded.
2 Good.
3 Pretty good.
4 Late; doubtful; clouds passing, frequently hiding planet.
5 Very good.

Observations interfered with by passing clouds, but splendid glimpses occasionally, the planet and satellites being splendidly defined, the latter, excepting the fourth, having well-defined disks. The fourth satellite, before ingress, was noticed as faint, and, when on the planet's disk, it appeared as a black, well-defined spot on the northern white belt, almost as black as its shadow, which was then passing off the opposite limb. The transit occurred on the north bright belt.

6, 7, 8 Not good; planet very badly defined.

9 Very good, but satellite disappearing close to the limb might cause the time noted to be a little early.

Ref. No.

10, 11, 12, 13, 14 Clouds interfering; the shadow and the satellite traversed the north edge of the north equatoreal white belt, and were almost touching each other.

15 Very good observation.
16 Observation doubtful; clouds continually obscuring planet, which, however, emerged just before time noted, and I then caught sight of satellite as a mere speck close to, but not touching the edge or limb of planet; the time noted was when it disappeared.
17 Late; not good; planet dreadfully ill defined and unsteady.
18 Not very good.
20 Considered good.
21 Late; clouds interfering.
23 Difficult.

Ref. No.	Date 1878	Observer.	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding Greenwich Mean Time. h m s	Time by *Nautical Almanac.* h m s	Apparent Error of *Nautical Almanac.* m s	Power.
24	July 26	R	III. Tr. E.	Bisection	11 51 57·85	2 37 36·55	2 41	...	200
25	,,	,,	III. Sh. E.	Internal contact	11 55 17·85	2 40 56·55	...	...	,,
26	,,	,,	III. Tr. E.	External contact	11 56 7·84	2 41 46·54	...	...	,,
27	,,	,,	III. Sh. E.	Bisected	11 56 49·34	2 42 28·04	2 47	...	,,
28	,,	,,	,,	Limb complete	12 1 37·83	2 47 16·53	...	...	,,
29	July 29	T	I. Tr. I.	External contact	8 26 26·30	23 12 5·00			
30	,,	,,	,,	Bisection	8 32 3·80	23 23 42·50	23 25	...	,,
31	,,	,,	,,	Internal contact	8 41 19·80	23 26 58·50			
32	July 29	T	I. Sh. I.	First seen	8 45 54·30	23 31 33·00			
33	,,	,,	,,	About bisected	8 47 38·30	23 33 17·00	23 32	...	,,
34	,,	,,	,,	Internal contact	8 49 46·30	23 35 25·00			
35	July 29	T	I. Tr. E.	Internal contact	10 54 50·00	1 40 28·70			
36	,,	,,	,,	About bisected	10 57 5·00	1 42 43·70	1 45	...	,,
37	,,	,,	,,	External contact	11 0 8·05	1 45 47·20			
38	July 29	T	I. Sh. E.	Internal contact	11 1 4·00	1 46 42·70			
39	,,	,,	,,	About bisected	11 2 13·00	1 47 51·70	1 52	...	,,
40	,,	,,	,,	Limb complete	11 4 31·00	1 50 9·70			
41	Aug. 7	T	I. Tr. E.	Internal contact	7 4 45·68	21 50 24·38			
42	,,	,,	,,	About bisection	7 6 58·68	21 52 37·38	21 55	...	,,
43	,,	,,	,,	External contact	7 9 0·18	21 54 38·88			

44	Aug. 9	R	II.	Ec. R.	First seen	7 48 25·60	22 34 4·30	22 34 52	+0 47·70	,,
45	,,	,,		,,	Full blaze	7 54 15·10	22 39 53·80	...	...	,,
46	Aug. 13	T	I.	Oc. D.	External contact	9 23 21·67	0 9 0·37			
47	,,	,,		,,	About bisected	9 25 12·17	0 10 50·87	0 11	...	,,
48	,,	,,		,,	Internal contact	9 27 58·67	0 13 37·37			
49	Aug. 13	T	III.	Ec. R.	First seen	9 54 32·10	0 40 10·80	0 43 28	+3 17·20	,,
50	,,	,,		,,	About bisection	9 58 49·10	0 44 27·80	...	...	,,
51	,,	,,		,,	Full blaze	10 1 59·10	0 47 37·80	...	...	,,
52	Aug. 13	T	I.	Ec. R.	First seen	12 12 0·80	2 57 39·50	2 57 48	+0 8·50	,,
53	,,	,,		,,	Full blaze	12 16 33·80	3 2 12·50	...	...	,,
54	Aug. 21	T	I.	Tr. In.	External contact	8 16 25·80	23 2 4·50			
55	,,	,,		,,	About bisected	8 19 22·30	23 5 1·00	23 5	...	,,
56	,,	,,		,,	Internal contact	8 22 2·78	23 7 41·48			

Remarks.

Ref. No.

28 When shadow disappeared the satellite was only about half its diameter outside the limb of the planet.
31 Satellite entered on northern edge of equatoreal bright belt.
32 Limb slightly indented.
35
36 Considered good.
37
39 Appearing as a cup to satellite.
41
42, 43 Definition wretched; planet very unsteady; limb boiling; lost egress of shadow by clouds.

Ref. No.

44 Very exact; seen instantly; definition good.
46, 47, 48 Very exact; planet and satellite very well defined; occultation complete at limb; satellite disappeared behind bright equatoreal belt, and a little south of equator.
49, 50, 51 Definition splendid; satellite well defined; and at time noted of bisection it appeared as a half-moon.
54 Not very good; planet unsteady.
56 Very good.

Ref. No.	Date 1878.	Observer.	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding Greenwich Mean Time. h m s	Time by *Nautical Almanac*. h m s	Apparent Error of *Nautical Almanac*. m s	Power.
57	Aug. 21	T	I. Sh. I.	First seen	8 58 55·20	23 44 33·90			
58	,,	,,	,,	Bisected	8 59 29·70	23 45 8·40	23 44	...	200
59	,,	,,	,,	Internal contact	9 1 33·70	23 47 12·40			
60	Sept. 25	T	III. Ec. R.	First seen	10 0 21·38	0 46 0·08	0 49 40	+3 39·92	,,
61	,,	,,	,,	Full blaze	10 12 38·38	0 58 17·08	...	...	,,
62	Sept. 30	T	I. Ec. R.	First seen	7 9 57·13	21 55 35·83	21 55 50	+0 14·17	,,
63	,,	,,	,,	Full blaze	7 13 7·63	21 58 46.33	...	...	,,
64	Oct. 1	T	II. Oc. D.	External contact	9 53 25·20	0 39 3·90			
65	,,	,,	,,	About bisected	9 55 28·20	0 41 6·90	0 41	...	,,
66	,,	,,	,,	Internal contact	9 57 49·20	0 43 27·90			
67	Oct. 2	T	III. Oc. R.	First seen	8 54 39·30	23 40 18·00			
68	,,	,,	,,	About bisection	8 57 28·30	23 43 7·00	23 46	...	,,
69	,,	,,	,,	External contact	9 1 34·30	23 47 13·00			
70	Oct. 2	T	III. Ec. D.	Disappearance	10 34 47·50	1 20 26·20	1 20 52	+0 25·80	,,
71	Oct. 5	T	IV. Ec. D.	Minute speck	8 20 38·62	23 6 17·32	...	...	,,
72	,,	,,	,,	Still visible	8 22 15·12	23 7 53·82	...	...	,,
73	,,	,,	,,	Disappearance	8 22 37·62	23 8 16·32	23 10 19	+2 2·68	,,
74	Oct. 21	T	I. Oc. D.	External contact	9 16 19·54	0 1 58·24			
75	,,	,,	,,	About bisected	9 17 55·54	0 3 34·24	0 4	...	,,
76	,,	,,	,,	Disappeared	9 20 34·04	0 6 12·74			

77	Oct. 23	R	I.	Ec. R.	First seen	7 25 4·46	22 10 43·16	22 10 46	+0 2·84	„
78	„	„		„	Quite distinct	7 25 19·96	22 10 58·66	...	...	„
79	„	„		„	Full blaze	7 27 48·96	22 13 27·66	...	...	„
80	Oct. 28	T	I.	Oc. D.	External contact	11 13 8·22	1 58 46·92	2 0	...	„
81	„	„		„	About bisected	11 14 38·22	2 0 16·92			
82	„	„		„	Last seen	11 16 23·22	2 2 1·92			
83	Nov. 7	R	IV.	Oc. D.	External contact	8 34 29·72	23 20 8·42	23 29	...	300
84	„	„		„	About bisected	8 37 33·22	23 23 11·92			
85	„	„		„	Seen through limb	8 39 22·71	23 25 1·41			
86	„	„		„	„ „	8 40 24·71	23 26 3·41			
87	„	„		„	„ „	8 41 38·20	23 27 16·90			
88	„	„		„	Internal contact	8 41 54·69	23 27 33·39			
89	„	„		„	Last seen	8 41 59·69	23 27 38·39			

Remarks

Ref. No.

57 Late; limb indented.

58

59 Good observations.

62, 63 Good observations; well defined; first seen as a minute speck of light.

64

65, 66 All good; satellite disappeared behind equatoreal cloud belt.

68 Too soon; emerged from behind southern dark band, near its polar margin; satellite slightly separated from limb; observations considered good, but planet not very well defined except in glimpses.

Ref. No.

70 Very good and exact; fourth satellite very faint.

73 Considered exact, but lost sight of satellite several times before final disappearance; planet not well defined; Moon a little to east of planet.

74, 75, 76 Very badly defined, but observations pretty good; at times I thought satellites could be seen through edge of planet, but not certain.

77 Good, sharp, and exact; definition of planet fair.

78 As distinct as a small star, to the north, between two satellites to the east of No. 1.

80, 81, 82 Not very good; badly defined and very unsteady.

Ref. No.	Date 1878.	Observer.	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding Greenwich Mean Time. h m s	Time by *Nautical Almanac*. h m s	Apparent Error of *Nautical Almanac*. m s	Power.
90	Nov. 7	R	III. Ec. R.	First seen	10 8 33·53	0 54 12·23	0 57 39	+3 26·77	200
91	,,	,,	,,	Quite distinct	10 9 27·03	0 55 5·73	...	...	,,
92	,,	,,	,,	As bright as adjoining Sat. No. II.	10 12 39·53	0 58 18·23	...	...	,,
93	,,	,,	,,	Full blaze	10 15 0·52	1 0 39·22	...	...	,,
94	Nov. 13	T	I. Oc. D.	External contact	9 34 58·15	0 20 36·85			
95	,,	,,	,,	About bisected	9 36 51·15	0 22 29·85	0 24	...	,,
96	,,	,,	,,	Internal contact	9 38 55·15	0 24 33·85			
97	Nov. 15	R	I. Ec. R.	First seen	7 39 43·23	22 25 21·93	22 25 28	+0 6·07	,,
98	,,	,,	,,	Quite distinct	7 40 4·23	22 25 42·93	...	...	,,
99	,,	,,	,,	Full blaze	7 42 7·23	22 27 45·93	...	...	,,
100	Dec. 11	T	IV. Ec. D.	Disappearance	9 0 14·80	23 45 53·50	23 49 3	+3 9·50	125

Remarks.

Ref. No.

83 May be a little too soon.

88 Satellite passed behind white cloud belt at about lat. 25° or 30° S.

89 Fancied I saw it at 5″ after internal contact, but not very certain; definition good and steady. Looked for egress of shadow of first satellite, but could not see it.

90 Very minute speck of light; caught the first glimpse; very good observation.

91, 92, 93 Very good observations.

94, 95, 96 Mere guesswork; planet and satellites most wretchedly defined.

97, 98, 99 Not considered first-rate; hazy, and definition bad.

100 Very good; a mere speck for last minute or more; planet dreadfully ill defined.

[*The Notes of the Physical Appearance of Jupiter etc., accompanying the foregoing observations are unavoidably deferred.*—Ed.]